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No. 49

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USSR AND EASTERN EUROPE SCIENTIFIC ABSTRACTS  
MATERIALS SCIENCE AND METALLURGY

No. 49

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## Aluminum and Its Alloys

USSR

UDC 669.715:620.186

### THE STRUCTURE OF Al-Mg ALLOYS WITH TITANIUM AND ZIRCONIUM

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian  
No 6, 1977 pp 62-63

AFANAS'YEV, V. K. and ABRAMOV, A. A., Krasnoyarsk Institute of Nonferrous  
Metals imeni M. I. Kalinin

*[Abstract]* A study is made of the factors determining the appearance of brittle metallides in aluminum alloys. Trinary Al-Mg-Ti and Al-Mg-Zr alloys were studied. The magnesium content was constant (11%), the quantity of titanium and zirconium was varied from 0.05 to 1.5%. The experiments confirmed the assumption that one necessary condition for the formation of metallides of titanium and zirconium in aluminum alloys is the presence of hydrogen. Figures 2; References: 5 Russian.

USSR

UDC: 669.715:620.1

### LONG-TERM STRENGTH OF SHEETS AND WELDED JOINTS OF THE ALUMINUM ALLOYS 1201, 1911 and AMg6

Moscow TSVETNYYE METALLY in Russian No 5, May 77 pp 69-71

VOROB'YEV, N. A., BICH, E. N. and FROL'TSOVA, T. A.

*[Abstract]* The purpose of this work was to study the long-term strength at room temperature of the alloys mentioned in the title. The base materials were studied using both smooth and notched specimens cut in the transverse direction with gauge section widths of 10 mm for smooth specimens, lengths of 25 and 37 mm, thicknesses of 2 and 5 mm. The notched specimens were 10 mm in width, 13 mm outside the notched area, with notch aperture angle 45°, notch tip radius 0.1 mm. Under short-term tensile loading of smooth specimens, the strongest base material was alloy 1201 5 mm thick, the weakest--AMg6. Sheets of 1201 and 1911 showed a greater tendency toward strength loss than sheets of AMg6, apparently due to their differing deformation capability and structural stability. The long-term strength of the base metal and of welded joints of sheets of these alloys depends on their chemical composition, thickness of the material and the presence of stress concentrators. Extrapolation indicated that the

maximum strength loss in 20,000 hours for 1201 and 1911 is 18-20%. The long-term strength (20,000 hours) of welded joints in the alloys AMg6 and 1911 is 13-15% less, in alloy 1201--6-10% less than the short-term tensile strength.

USSR

UDC 620.172.251.1

REGULAR FEATURES OF THE DEFORMATION OF AMg6 ALLOY IN THE TWO-DIMENSIONAL STRESSED STATE UNDER LOW-TEMPERATURE CONDITIONS

Kiev PROBLEMY PROCHNOSTI in Russian No 4,1977 pp 3-6 manuscript received 30 Apr 76

KOVAL'CHUK, B. I., and LEBEDEV, A. A., Kiev

Abstract Results are given from an experimental study of the regular features of the deformation of AMg6 aluminum-magnesium under uniaxial and biaxial extension at room temperature and low temperatures, specifically at 20, -100, and -160°C. There have been practically no studies on the influence of the type of stressed state on the regular features of low-temperature deformation and failure of alloys of this type. Studies were conducted with thin-walled tube specimens with an inside diameter of 25 mm and a wall thickness of 1 mm, made from hot-rolled rods 45 mm in diameter. Testing was performed with an SNT-5P unit, furnished with a system for automatic control and automatic gathering of experimental data, by applying an axial force and inside pressure. The experimental data were processed in terms of true stresses and strains. A study was made of the influence of temperature and the type of stressed state on the alloy's elastic stiffness and plastic limit, as well as of the relationship between the alloy's anisotropy parameters and the degree of plastic deformation. Curves showing the relationship between deformation and temperature with different ratios between major stresses demonstrate that this alloy has greater elastic stiffness and higher plasticity under axial extension than under tangential extension. Lowering the temperature leads to an increase in the alloy's strength and a change in plasticity. Curves for plastic limit versus temperature with different ratios between major stresses demonstrate that plasticity increases regardless of the type of stressed state with a reduction in temperature. A comparison is made between experimental and calculated data obtained on the basis of employing a theory for establishing the relationship between the stressed and strained states of an

anisotropic solid suggested in an earlier study. It is demonstrated by curves showing the relationship between the anisotropy parameters employed in this theory and the degree of plastic deformation at various temperatures that these anisotropy parameters change only slightly in the deformation process and are virtually independent of temperature. A more detailed analysis showed that under certain conditions there is a tendency toward some reduction in the anisotropy of the alloy's elastic stiffness with a reduction in temperature. Generalized deformation curves are given for this alloy. Good agreement was obtained between experimental and calculated deformation curves for this alloy with different ratios between major stresses at room and low temperatures. Figures 4; References: 5 Russian.

## Beryllium

USSR

UDC 669.889:620.170

### FEATURES OF THE FAILURE OF HOT-EXTRUDED BERYLLIUM WHEN TESTING FOR IMPACT STRENGTH, STATIC TENSION AND FATIGUE

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 43, No 2, Feb 77 pp 434-437 manuscript received 26 Apr 76

KANCHEYEV, O. D., POLITIKO, S. K., and YERMOLAYEV, O. N.

Abstract To discover the mechanism for the origin and development of cracks in metal-ceramic beryllium, a study was made of fractures in specimens of hot-extruded beryllium with an initial grain size of 56 microns after testing for static tension, for fatigue with a "tension-compression" loading cycle, and for impact strength, using Charpy specimens and smooth specimens, in the -196 to 800°C range. Fractographic studies were made with an MIM-7 optical microscope, with a UEMV-100K electron microscope, using the method of two-stage collodion-carbon replicas, and with a scanning electron microscope. Failure in these specimens began with an intergranular crack. A study of the zone of crack origin and stable growth showed that the crack develops in this zone exclusively along grain boundaries. The crack originated deep within the specimen (when testing for static tension) or in the zone beneath the surface at a depth of not less than two to three times the diameter of grains. When the zone of stable crack growth reached a critical value, when the strength of stressed at the edge of the crack reached a maximum, the crack spread in avalanche fashion and the specimen fractured. In the zone of avalanche-type crack growth, within the -196 to 300°C range, fracture occurred primarily inside grains (shear). There was practically no transitional region observed between zones of stable and avalanche-type crack growth. Comparison of the variation in impact strength of beryllium with temperature for smooth specimens and specimens with a notch demonstrated that this material is highly sensitive to stress concentrators. Failure is of the brittle sort throughout the temperature range studied (20 to 800°C); zones of quasi-ductile fracture are found at 800°C, after testing for impact strength. In the case of static tension, these zones are encountered at 100°C and are quite pronounced at 400 to 500°C. Fracture is of a ductile nature above 700°C. In cyclic fatigue tests fracture becomes ductile at 600°C. The data presented demonstrate that beryllium can experience brittle failure even at 700 to 800°C under certain conditions, especially with the presence of stress concentrators. In their absence extruded beryllium can have sufficiently high impact strength. The data of fatigue tests and fractographic studies prove that it is feasible to use extruded beryllium, in the absence of stress concentrators, as a structural material for temperatures above 200°C. The

main reason for intergranular crack origin and growth is the fact that flaws accumulate along grain boundaries under strain, as shown by a study of the dislocation structure of the active zone of specimens after testing for static tension and fatigue. When the test temperature increases, the material's ductility increases and the strain in the beryllium increases to the origin of avalanche-type crack spreading, as a result of which the number of flaws at grain boundaries grows, and intercrystallite failure is facilitated. Figures 4; References 11: 6 Russian, 5 Western.

Composite Materials

USSR

UDC 620.195

TIMOFEYeva, N. I., FROLOVA, K. I. and KRAYNOVA, Z. I., All-Union Scientific Research Institute of Aviation Materials

CORROSION RESISTANCE OF NICKEL-RARE EARTH SESQUIOXIDE COMPOSITES IN WATER

Moscow ZASHCHITA METALLOV in Russian Vol 13, No 4, Jul-Aug 77 pp 443-444  
submitted for publication 26 Nov 75

*[Abstract]* Nickel-rare earth sesquioxide composites were prepared by hot sintering at 1050-1100°C under a pressure of 250 kgf/cm<sup>2</sup> and soaked at the terminal temperature for 30-40 minutes. Corrosion tests were conducted in boiling water for 100 hours and in water under pressure at 250°C for 24 hours. All samples had a smooth surface, no cracks and no loss of dimension or shape after testing, the only change being an increase in mass resulting from the formation of surface hydrates. Composites with lanthanum and neodymium oxides had a greater corrosion rate than the other oxides. Chemical analysis showed that the La and Nd oxides were soluble in water while the other rare-earth oxides were insoluble. A table shows the corrosion rate of the rare-earth oxides in water. References: 3 Russian, 1 Western.

USSR

UDC 666.762.14.001.5

THE STRUCTURE AND COMPOSITION OF MELTED MULLITE OBTAINED BY THE HIGH FREQUENCY HEATING METHOD

Moscow OGNEUPORY in Russian No 4, Apr 77 pp 40-46

SURKOVA, I. A., NIKITINA, N. M., BALKEVICH, V. L., and POLUBOYARINOV, D. N. (deceased), Moscow Institute of Chemical Technology imeni D. I. Mendeleyev; GARANIN, V. K., Moscow State University; OSIKO, V. V., ALEKSANDROV, V. I. and TATARINTSEV, V. M., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR

*[Abstract]* Specimens were prepared containing various combinations of SiO<sub>2</sub> and Al<sub>2</sub>O<sub>3</sub> from quartz sand of the Tashlin deposit and technical alumina. The charge was hand-mixed and smelted using an electrothermal process for 1.5-2 hours. Tests were then conducted on the four zones of surface, center, bottom, and periphery, since they showed unequal rates of crystallization.

Petrographic, x-ray, chemical and microspectral x-ray analyses were made. Results indicated that the forming mullite crystals extracted Al<sub>2</sub>O<sub>3</sub> from the smelt, and the changing content of Al<sub>2</sub>O<sub>3</sub> should be regarded as an aspect of transformations related to this process. Charges containing from 69 to 75% Al<sub>2</sub>O<sub>3</sub> and, correspondingly, 31 to 25% SiO<sub>2</sub> yielded a durable phase composite of mullite and glass. Only isolated corundum crystals appeared. The most useful for producing refractory materials was that with the highest Al<sub>2</sub>O<sub>3</sub> content. Supplemental annealing contributes to the formation of mullite from the glass phase; if ceramics technology is used no preliminary annealing is necessary. Figures 6; References 8: 5 Russian, 3 German.

USSR

UDC 620:186:666.762.5:669.3

AN INVESTIGATION OF ARTICLES OF ZIRCONIUM-CONTAINING COMPOSITE MATERIALS  
AFTER USE IN CASTING COPPER

Moscow OGNEUPORY in Russian No 4, Apr 77 pp 38-39

KOEMETS, N. A., KUZ'MIN, L. I. and KUDRYAVTSEVA, T. N., Eastern Institute of Refractories

Abstract Metal ducts were coated with a refractory solution of zirconium dioxide (85%) and clay (15%), and with a magnesium phosphate solution, to a thickness of 0.5-1.0 mm. The resulting ducts had a crushing strength of 300--320 kg/cm<sup>3</sup>, heat resistance up to 1350°C, thermal cycling of 30, and fire resistance of 1710--1730°C. The ducts were used for continuous casting of copper at 1180-1200°C for 5--5.5 hours. No dimensional changes or deformations were observed; copper and copper oxide penetration was 0.5-1.5 mm. The glass-like structure, composed of fine filaments (0.006 mm in thickness), developed thermal fractures but maintained its basic form, with cuprite and metallic copper forming in the fissures. Results indicated that the composite material is suitable for use in the continuous casting of copper. Figures 1; References: 2 Russian.

USSR

UDC 669.71:669.3

STUDY OF THE ELECTRIC PROPERTIES OF COPPER-CARBON FIBER COMPOSITES AT CRYOGENIC AND HIGH TEMPERATURES

Moscow FIZIKA I KHIMIYA OBRABOTKA MATERIALOV in Russian No 3, May-Jun 77  
pp 132-135 manuscript received 14 Dec 76

KUZ'MIN, A. M., VOLGA, V. I., IZOTOVA, Ye. M. and TERENT'YEVA, L. M.,  
Moscow

*[Abstract]* Results are presented from an experimental study of the temperature variation of resistivity in the 77-550°K temperature interval for composites with various volumetric contents of carbon fiber (17-63%). It is shown that the experimental value of resistivity throughout the entire temperature range studied, within the limits of error of the experiments, agrees with the calculated values determined from the law of additive conductivity. Studies of the variation in conductivity of copper-carbon fiber composites with volumetric fraction of the reinforcing component indicate that the resistivity varies between 0.0025 and 0.088 ohm·m<sup>2</sup>m, with a variation in fiber content of 17 to 63% and can be calculated as the resistance of parallel conductors. Figures 2; References: 7 Russian.

USSR

UDC 669.71

STUDY OF THE INTERACTION OF SILICON CARBIDE FIBERS WITH A MATRIX OF COMPLEX NICKEL ALLOY

Moscow FIZIKA I KHIMIYA OBRABOTKA MATERIALOV in Russian No 3, May-Jun 77  
pp 127-131 manuscript received 19 Nov 76

IVANOV, V. K., KUT'YENKOV, V. A., SHULEPOV, V. I., GUZEY, L. S.,  
SOKOLOVSKAYA, YE. M. and DOROKHOVICH, V. P., Moscow, Kiev

*[Abstract]* A study is made of the composition of the products of interaction between components of a composite material with a matrix of complex nickel alloy, reinforced with silicon carbide fibers. These products consist of silicides such as Me<sub>2</sub>Si, Me<sub>5</sub>Si<sub>3</sub> and MeC carbide. Thermodynamic analysis of possible reactions shows that at 1100°C, silicon carbide is incompatible with nickel alloys. The layer of interaction products does not have significant barrier properties. One important means for increasing

compatibility is alloying of the nickel with metals which, upon interaction with silicon carbide, can form a layer of products inhibiting the development of further interactions. It is for this reason that the complex alloy ZhS6, containing significant quantities of strong carbide and silicide formers, was tested. The interaction between the fibers and matrix occurs so rapidly that a fiber 100  $\mu$ m in diameter is completely destroyed in the process of production of the composite by hot pressing at 1100°C. This indicates ineffectiveness of natural coatings as a means for increasing the compatibility of silicon carbide fibers with complex nickel alloy matrices. Figures 2; References 7: 6 Russian, 1 Western.

USSR

UDC 669.71:536.413

X-RAY INVESTIGATION OF RESIDUAL STRESSES IN ALUMINUM COMPOSITES REINFORCED WITH BORON FIBERS

Moscow FIZIKA I KHIMIYA OBRABOTKA MATERIALOV in Russian No 3, May-Jun 77  
pp 121-126 manuscript received 20 Apr 76

SAMOYLOV, A. I., SVETLOV, I. L., KRIVKO, A. I., CHUBAROV, V. M. and SAKHAROV, V. V., Moscow

Abstract Results are presented from mechanical testing and x-ray investigation of thermal stresses in aluminum-boron fiber (Al-B) and D16 aluminum alloy-boron fiber ( $D_{16}$ -B) composites after manufacture by hot pressing using various temperature-time combinations and after several heat treatment modes. The x-ray method determines the thermal stresses; it is demonstrated that after pressing, tensile stresses arise in the matrix, equal in order of magnitude to the yield point. Treatment in liquid nitrogen converts the stresses to compressive stresses. The variation of internal stresses with temperature and time of pressing is studied. Hardening heat treatment (quenching plus aging as for D16 alloy) of D16-B composite does not change the nature or magnitude of internal stresses. Only liquid nitrogen cryogenic treatment can change the magnitude and direction of thermal stresses in the matrix at room temperature. There is a correlation between the internal stresses, characterizing the force of the interaction at the fiber-matrix boundary, and the strength of Al-B and D16-B composites in both the axial and transverse directions. Figures 4; References 13: 9 Russian, 4 Western.

USSR

UDC 621.762.001.541.1+669.01.84

ON THE POSSIBILITY OF USING PROTECTIVE COATINGS OF ALUMINUM OXIDE ON  
SILICON CARBIDE FIBERS IN NICHROME-BASED COMPOSITES

Kiev POROSHKOVAYA METALLURGIYA in Russian No 6, Jun 77 pp 36-41 manuscript  
received 26 May 76

KARPINOS, D. M., LISTOVNICHAYA, S. P., DZEGANOVSKIY, V. P. and BALAKHNINA,  
V. N., Institute of Problems of Material Science, Academy of Sciences  
UkrSSR

[Abstract] A study is made of the possibility of using aluminum oxide coatings on silicon carbide fibers in a nichrome (Kh20N80) matrix. First of all, the compatibility of silicon carbide and aluminum oxide in the process of formation and subsequent annealing of specimens at 1200, 1500 and 1700°C for 10-30 hours was studied. The specimens produced were analyzed on an IKS-21 infrared spectrometer by charge dispersion in potassium bromide, specimens having been prepared by hot pressing in graphite press molds at 1700°C for 15 minutes at 80 kg/cm<sup>2</sup>. The results of the analysis showed that in the process of formation of specimens and annealing at 1100-1200°C, no interaction occurs between the components, but that initial interaction begins at temperatures over 1400°C. Primary attention was turned to the selection of a method of application of coatings to provide for sufficiently thick coatings at relatively low precipitation temperatures in order to avoid recrystallization of the fibers and interaction between the load-bearing tungsten core and the silicon carbide, which would reduce strength. The method of thermal decomposition of aluminum acetylacetone was studied. Photographs are presented of the microstructure of model specimens of the composites. It was found that coatings 1.5-2  $\mu$ m thick provided stability of the boundary between the fiber and the matrix; annealing for 5-15 hr at 1100-1200°C produced clearly expressed diffusion zones in the form of concentric circles around the tungsten core. It is concluded that coatings of aluminum oxide retard mass transfer through the fiber-silicon carbide-nichrome matrix division boundary and can be used at temperatures of up to 1100°C, with service lives on the order of 50 hours. Higher temperatures and longer times result in extremely complex processes of interaction accompanied by the formation of intermediate phases such as metal carbides and silicides, as well as solid solutions based on them, causing complete degradation of the silicon carbide fiber. Figures 4; References 12: 8 Russian, 4 Western.

USSR

UDC 661.66

PROPERTIES OF CARBON-CARBON COMPOSITE MATERIALS SUCH AS SYNTACTIC FOAMS

Moscow IZVESTIYA AKADEMII NAUK SSSR. NEORGANICHESKIYE MATERIALY in Russian  
Vol 13, No 6, Jun 77 pp 1009-1012 manuscript received 19 Feb 76

VIRGIL'YEV, Yu. S., VOLKOV, G. M., ZAKREVSKIY, Ye. A., LOPATTO, Yu. S. and  
MAKARCHENKO, V. G.

Abstract Carbon-carbon composites called syntactic foams can operate at high temperatures and have good heat insulating properties. They are based on nitrogen-filled hollow carbon microspheres 10 to 1000  $\mu\text{m}$  in diameter with wall thicknesses of 3-50  $\mu\text{m}$ , produced by slow carbonization of phenol microspheres in a protective medium. The heat insulating capacity of carbon microspheres is great, exceeding that of glass microspheres and comparable to the properties of carbon black. The material of the microspheres is resistant to the effect of most corrosive fluids and gases at room temperature and elevated temperatures, and the substance does not oxidize in air at up to 600°C. Electron microscope and x-ray structural studies have shown that the material of the envelopes is similar in structure to vitrious carbon. By binding the carbon microspheres together by mixing them with any type of carbon binder with subsequent carbonization of the composite in a neutral atmosphere at temperatures up to 1000°C, the composite material known as syntactic foam is produced. The materials thus produced are distinguished by low weight per unit volume, high strength and low heat conductivity, resistance to acids, melted salts, alkalis, etc. and oxidation in air at up to 600°C. In oxygen-free media, they can be used at up to 3000°C. It is found that the bending and compressive strength, modulus of elasticity, resistivity, and coefficient of thermal expansion depend exponentially on the total porosity of specimens of various volumetric weights. Low-temperature neutron bombardment causes the strength properties to increase without changing resistivity; radiation shape change is manifested as compression of the specimens, proportional to the coefficient of thermal expansion. Figures 4; References 13: 7 Russian, 6 Western.

USSR

UDC 620.171.5:669.12'27'28

FEATURES OF THE DEVELOPMENT OF MICROPLASTIC DEFORMATION IN COMPOSITE MATERIALS BASED ON IRON

Kiev PROBLEMY PROCHNOSTI in Russian No 4, 1977 pp 84-87 manuscript received 16 Jul 76

GOLOVIN, S. A. and RENNE, I. I., Tula Polytechnical Institute

**[Abstract]** The method of photoelastic coatings is used to obtain data on the distribution of strains near the skeleton-filler phase interface in a composite powder material based on iron and impregnated with a ferro-copper hardener. Studies were made by bending flat specimens and analyzing them by the polarization method with application of a photoelastic coating. Parameters of illumination intensity at points on the interference pattern were determined by photometric evaluation of negatives of shots taken from two different angles between the specimen and polarization plane. A "Nairi-K" computer was used to calculate averaged fields for different major strains from the parameters of interference patterns. Fields of micro-strains in a section of the composite material computed in this way show that near the iron skeleton - ferro-copper filler phase interface is observed elevated deformation of the iron skeleton with a considerable gradient in strains at boundaries. Unimpregnated pores also act as sources of elevated strain. Sections of elevated strain are located chiefly at abrupt breaks at interfaces. With an increase in strain in the specimen on the macro level regions of elevated strain increase while maintaining their original positions. It was observed in the majority of instances that the strain in the filler is less than that in the skeleton, an unexpected result indicating that it is probable that the very nature of the inhomogeneity of the stressed state near the phase interface must impose certain conditions on the development of microplasticity in the individual components of the material. A simplified analysis is made of the nature of the origin of plastic flow in components of the material near the phase interface, assuming that the phases are ideally elastoplastic. It is demonstrated that in the case of proximity between the yield points of the inclusion and skeleton with a strong difference in their elastic properties the possibility of the origin of plastic flow in the stiffer phase first cannot be eliminated. Figures 2; References: 8 Russian.

Conferences

USSR

PHYSICAL CHEMISTRY, STRUCTURE AND TECHNOLOGY OF POLYMERIC COMPOSITES  
(FOURTH REPUBLICAN CONFERENCE ON HIGH MOLECULAR COMPOUNDS IN  
SEVERODONETSK)

Kiev VISNYK AKADEMIYI NAUK UKRAYINS'KOYI RSR in Ukrainian No 3, Mar 77 p 91

DRYAGILYEVA, R. I., Candidate of Chemical Sciences

Abstract The conference, at which close to 200 representatives from academic institutions and industry were present, was held in September of 1976 in Severodonetsk, Ukrainian SSR. Among the most plenary reports were those of Academician Yu. S. Lipatov on physical chemistry and structure of polymeric composites; Doctor of Chemical Sciences M. K. Akutin and Doctor of Technical Sciences G. A. Blokh on property improvements of composites; and Doctor of Chemical Sciences S. I. Omel'chenko on curring the polymeric composites by radiation. Reports presented at two sections (the physical chemistry and structure of composites; chemistry and technology of polymeric composites) concerned the following topics: a) the theory of catalysis and the mechanism of three-dimensional structures in polymers; b) phenomena that take place at the interface of polymer-solid body; c) the theory of interpenetrating networks and properties of systems formed by them; d) new vulcanizing and modifying agents in the rubber industry; e) alloying of bulk polymers with small additions of other polymers; f) surface modification of fillers and reinforcing materials; and g) production of glass fiber reinforced plastics and their industrial use.

Corrosion

USSR

UDC: 669.295:620.193.43

GAS CORROSION OF MAGNESIUM-REDUCTION TITANIUM PRODUCTION APPARATUS

Moscow TSVETNYYE METALLY in Russian No 5, May 77 p 44

PUTINA, O. A., PUTIN, A. A., BONDAREVA, E. P. and KOKSHAROVA, M. A.

*[Abstract]* The factors causing failure of reactors used in the magnesium-reduction process of production of titanium were studied using specimens of Kh18N10T steel 2 x 20 x 40 mm with an aperture 5 mm in diameter for mounting of the specimens. The specimens were polished, cleaned with alcohol, dried, measured and weighed, then exposed to the conditions in the reactor, and the mean corrosion rates of the specimens in the reducing and separation furnaces were determined. It was found that surface damage increased with each reaction cycle and that grain size increased beginning at the center of the specimen, small grains disappearing entirely after 5 cycles. The studies showed that gas corrosion of the material of the reaction in reduction and separation furnaces is one of the main causes of reactor wall failure.

USSR

UDC 620.194.8

MECHANISM OF THE CORROSION FATIGUE OF STEELS

Kiev VISNYK AKADEMIYI NAUK UKRAYINS'KOYI RSR in Ukrainian No 3, Mar 77  
pp 5-14

VASYLENKO, I. I., Doctor of Technical Sciences, SIRAK, Ya. M., Candidate of Technical Sciences, KULTAN, B. I.

*[Abstract]* The cyclic strength of specimens of ShKh15 steel was studied in dehydrated and purified alcohols, distilled water and in air at room temperature. All specimens tested at 80-85 kg/mm<sup>2</sup> in isopropyl alcohol failed after several thousand cycles (50 Hz), while those tested in air withstood more than 10 million cycles. The alcohol decreased the fatigue limit of steel specimens by 20-30% in comparison with specimens tested in dry air. This is attributed to a decrease in the surface energy of the steel due to the alcohol. Distilled water decreased the strength of steel specimens much more than alcohol. This was proved experimentally after subjecting the specimens to 6 million cycles at 20 kg/mm<sup>2</sup>, followed by

heating up to 100°C (until all water evaporated) and testing in dry air. A decrease in the fatigue strength of these specimens is attributed to small surface corrosion nuclei (up to 350  $\mu$ m in depth) which could initiate the corrosion fatigue cracks. However, when specimens in distilled water were subjected to stresses of 60 kg/mm<sup>2</sup>, they failed after only 10,000-30,000 test cycles, i.e., over a period of time insufficient for the development of surface corrosion. A decrease in the fatigue strength in this case is also attributed to a lower steel surface energy due to high stresses in a corrosive medium. The higher the decrease of the steel surface energy in a given medium, the greater the drop in the steel fatigue strength. The electrochemical theory of the corrosion fatigue of metals is briefly reviewed in relation to the metal surface energy.

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Glass and Ceramics

USSR

UDC 666.775

KINETICS OF GAS EVOLUTION FROM ORGANOSILICON BINDERS DURING PRODUCTION OF  
BORON-NITRIDE CERAMICS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 77 pp 44-47 manuscript  
received 14 Jan 77

MAZAYEV, V. A., PODOBEDA, L. G., KOROLEV, A. YA., and POLYAKOVA, E. N.,  
Moscow

[Abstract] The evolution of gas, as a result of thermal breakdown, is an important parameter to consider in the calcination of boron nitride with organosilicon binders into ceramic products. This process was studied by the thermovolumetric method rather than the thermogravimetric method, since the weight loss is too small to permit precise readings by the latter method. Both differential curves are shown here depicting the rate of gas evolution, as a function of the temperature during heating up to 850°C, from boron nitride alone, from polymethyl silasan, from a mixture of the two (97% BN), and from polymethyl siloxan resin. These curves reveal the main process stages and should be useful for optimizing the production of ceramics.

Figures 3; References: 2 Russian.

## Heat Treatment

USSR

UDC 621.78:669.295

### NEW MODES OF HEAT TREATMENT OF TITANIUM ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 8, 1977 pp 49-52

KOLACHEV, B. A., Moscow Aviation Technological Institute

*[Abstract]* Several new methods of heat treatment of titanium alloys are analyzed. The most promising methods of increasing the reliability of titanium alloy parts are vacuum annealing,  $\beta$  and pseudo- $\beta$  annealing and hardening with retulated cooling rates and subsequent aging.  $\beta$  annealing decreases the reduction in area, relative elongation and cyclic strength of titanium alloys. This negative influence of  $\beta$  annealing can be decreased by changing the parameters of the microstructure (dimensions of  $\beta$  grain,  $\alpha$  colonies and thickness of  $\alpha$  plates). The main means of increasing the hardenability of titanium alloys are additional alloying and regulation of the cooling rate during hardening (soft quenching). These result in reduced warping of parts and greater stability of properties through the cross section of parts after subsequent aging. Figures 4; References 24: 15 Russian, 9 Western.

USSR

UDC 621.78:669.295

### HEAT-TREATMENT OF LARGE FORGINGS OF VT3-1 TITANIUM ALLOY

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 6, 1977 pp 65-66

ARKOVENKO, G. I., GREKOV, N. A. and SAZONOVA, T. N.

*[Abstract]* A circle 15 mm thick cut from a forging 1140 mm in diameter with a wall thickness of 100 mm and a height of 875 mm made of VT3-1 alloy was studied. The mechanical properties and structure were studied after 3 modes of heat treatment: I, ordinary annealing (heating to 850°C for 1 hour, cooling in air); II, heating to 870°C, 1 hr, cooling with the furnace to 650°C, holding 2 hr, cooling in air; III, heating to 870°C, 1 hr, cooling in air plus heating to 650°C, 2 hr, cooling in air. The third heat-treatment mode was found to be optimal, producing the minimum creep of the material in 800-hr tests at 100°C. Figures 3.

## Instrumentation and Equipment

USSR

### INSTALLATION FOR DYNAMIC TESTING OF MATERIALS OVER A BROAD TEMPERATURE RANGE

Moscow ZAVODSKAYA LABORATORIYA in Russian Vol 43, No 4, 1977 pp 502-503

KAYBYSHEV, O. A., SHARIF'YANOV, F. Sh. and CHERNYSH, V. V., Ufa Aviation Institute

**[Abstract]** An installation has been developed at the authors' institute for the tensile testing of metals and alloys under impact loading at speeds of 0.2-4 m/s over a broad temperature range. It consists of a loading unit, heating unit, measurement unit (measuring forces, deformations and temperatures) and apparatus for recording the measured quantities. The loading unit is based on a pendulum hammer; the specimen is loaded by dropping a weight held up by a lever which is retracted by an electromagnetic system. The force is transmitted to the specimen through a pusher and rod connected to the moving clamp of the loading system. Heating is by low-frequency electric current by means of a special thyristor interrupter, which is used to regulate the temperature and heating rate. The tensile force is measured electrically by means of a piezoelectric converter; deformations are also determined electrically by means of an inductive sensor capable of measuring deformations in the elastic and plastic areas of deformation. A diagram of the installation is presented, as well as a typical oscillogram for copper deformed at  $2 \cdot 10^1$  s<sup>-1</sup> and 500 C. Figures 2.

USSR

UDC 669.855:621.315.59

### INDUSTRIAL SYSTEM FOR THE CONTROL OF THE GROWTH OF SINGLE CRYSTALS

Moscow TSVETNYYE METALLY in Russian No 5, May 77 pp 49-53

SEMENENKO, S. A., CHERNETS, N. V., SHENDEROVICH, I. L. and SHUBSKIY, G. I.

**[Abstract]** A single complex of hardware for testing and control of the growth of single crystals, the "Monokristall" system, has been developed, increasing the productivity of the process and improving the quality of the single crystals produced. The system includes a complex of hardware for local information control systems corresponding to the state process control system (GSP) and regulates the following parameters: effective voltage

across heater, melt temperature, rotating speed of seed shaft drive and crucible drive according to a fixed program. The system also tests and digitally displays the basic mode parameters, and transmits the information for input to a control computer. The various parts of the unit are described and diagrammed. The system is constructed on the modular principle and is now in use in series production installations for the growth of semiconductor materials, providing an annual economic effect of 1 million rubles.

Figures 4.

Magnesium

USSR

UDC 669.296'721'794

STUDY OF PHASE EQUILIBRIA AND PROPERTIES OF Mg-Y-Zr MAGNESIUM ALLOYS

Moscow IZVESTIYA AKADEMII NAUK SSSR, METALLY in Russian No 3, May-Jun 77  
pp 218-221 manuscript received 19 Apr 76

DRITS, M. YE., PADEZHOVA, YE. M., and GUZEY, L. S., Moscow

*[Abstract]* Magnesium-yttrium alloys have excellent strength characteristics at room temperature and higher. Since zirconium is a principal element alloyed with magnesium, a study was made of Mg-Y-Zr ternary alloys containing up to 2% Zr and 20% Y. The test specimens were first annealed isothermally at 500°C or at 300°C in a helium atmosphere and then quenched in water. Microstructural analysis and electrical resistivity measurements revealed Mg<sub>24</sub>Y<sub>5</sub> and Zr phases in equilibrium with the  $\alpha$ -Mg solid solution, as well as a lower solubility of yttrium and zirconium in solid magnesium when present together. A lower annealing temperature reduces the solubility of yttrium appreciably. Mechanical tensile tests indicate a higher strength of Mg-Y-Zr alloys. Figures 4; References 8: 3 Russian, 5 Western.

## Mechanical Properties

USSR

UDC 669.018.2

### INFLUENCE OF AUSTENITE STABILITY ON THE MECHANICAL PROPERTIES OF ALLOYS HARDENED BY THERMOMECHANICAL TREATMENT AND AGING

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 43, No 2, Feb 77 pp 329-334 manuscript received 26 Jan 76

UVAROV, A. I., SAGARADZE, V. V., SAVEL'YEVA, A. V., and MALYSHEV, K. A., Institute of Metal Physics of the Ural Scientific Center of the Academy of Sciences USSR

[Abstract] An extremely favorable combination of high strength and high ductility has been found in austenitic steel, so-called "trip" steel, whose high ductility after hardening is due to the development of a martensite gamma-to-alpha transformation during straining in the process of mechanical testing. This paper is devoted to a study of the mechanical properties of stainless austenitic alloys hardened by VTMO [high-temperature mechanical treatment] followed by aging, in which the development of this transformation is possible in the process of plastic deformation when testing mechanical properties. A study was made of alloys having a different tendency to martensite formation during strain hardening, namely, of alloys N20Kh12T3, N18Kh12T3, and N15Kh12T3, which are essentially chrome-nickel-titanium austenitic steels, also containing small quantities of carbon, manganese and aluminum. Billets measuring 10 x 10 mm were heated to 1150° and strained by rolling with a 30-percent draft with continuous cooling from 1150 to 850°, after which they were air-cooled. This type of treatment imitates the industrial process of forging or rolling, combining hot plastic deformation and hardening in a single operation. After this VTMO the billets were aged at 650 and 700° for one to eight hours, after which specimens measuring 3 mm in diameter were cut from them for mechanical tests and magnetic measurements. Studies were made with an IM-4R tensile testing machine set at 1.2 mm/min. A study of the structure of the hardened alloys was made with optical and electron microscopes. The alloys studied differ chiefly in nickel content (in the range from 15 to 20%); therefore, after VTMO they have approximately identical properties. But there is a drastic difference in their properties after aging owing to the fact that the content of nickel influences the metastability of these alloys. The strength properties of these alloys increase after VTMO with an increase in the temperature and length of aging, with an 8-hour maximum. The nickel content shows a different influence on tensile strength and yield stress with aging. Whereas tensile strength increases (owing to an increase in austenite metastability) with less nickel in these alloys, yield stress is reduced. After aging for one hour at 700°C, alloys with 20, 18, and 15% Ni have a yield stress of 120,

115, and 100 kg/mm<sup>2</sup>, respectively. The reduction in yield stress is associated with the influence of the nickel content on the disintegration of the supersaturated solid solution during aging. It has been demonstrated that the change in mechanical properties which occurs when hardening these alloys by VTMO and aging is a function of their stability. Maximum ductility is achieved with optimum martensite transformation kinetics during tensile testing. Figures 5; References 10: 6 Russian, 4 Western

USSR

UDC 621.791.012

EFFECT OF INTERLAYER COMPOSITION ON STRUCTURAL CHANGES AND MECHANICAL PROPERTIES OF VK-VK, TK-TK, AND VK-U8(STEEL) WELDED JOINTS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 77 pp 25-28 manuscript received 18 Jun 76

MUKHA, I. M., KAL'NENKO, B. I., GNEDOVA, S. V., and BELOTSKIY, A. V., Kiev

Abstract A study was made to determine the effect of the interlayer material on structural changes within the diffusion zone and on mechanical properties of welded joints between various grades of hard alloys as well as between one grade of hard alloy and carbon steel. Three series of welded-joint specimens were produced, namely: 1) VK3 alloy to VK3 or VK20 alloy, 2) VK15 alloy to U8 steel, 3) T30K4 alloy to T30K4 alloy and T15K6 alloy to T15K6 alloy. The results of x-ray diffraction and microstructural analysis revealed that the cobalt content in hard alloys has an effect on the residual stresses in the joint. The more the two joined materials differ in their cobalt content, the higher the stresses and the lower the flexural strength become. An iron-nickel interlayer with 2 wt.% VK3 alloy is best for diffusion welding of VK15 alloy to U8 steel. Use of a nickel interlayer in diffusion welding of TK alloys yields lower thermal stresses than use of an iron interlayer. Figures 4; References: 3 Russian.

USSR

UDC 669.094.3:669.295

INFLUENCE OF LONG-TERM OXIDATION ON THE MECHANICAL PROPERTIES OF AT3 AND AT6  
TITANIUM ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 8,  
1977 pp 58-60

KORNILOV, I. I., (deceased), BORISKINA, N. G., KENINA, YE. M., Institute  
of Metallurgy imeni A. A. Baykov

[Abstract] A study is made of the influence of long-term annealing in air (25-500 hr) at 600, 700 and 800°C on the mechanical properties of AT3 and AT6 alloys. Specimens were cut from pressed bars. Specimens 5 mm in diameter and 30 mm in length were tensile tested at 1.5 mm/min. Impact toughness was determined using standard specimens. The specimens were oxidized at 600, 700 and 800°C in air for 25, 50, 100, 250 and 500 hrs at each temperature. Annealing in air at 600 and 700°C up to 100 hrs had little effect on the strength or ductility of AT3, and decreased the strength and yield point of AT6 by 5-8 kg/mm<sup>2</sup>. Annealing at 800°C greatly reduced the strength and ductility of both alloys. The primary influence on the mechanical properties annealed at 600 and 700°C was that of a change in the structure of the core of the specimen, and to a lesser extent a change in the depth of the gas-saturated layers. References: 5 Russian.

Powder Metallurgy

USSR

UDC 669.295+621.762

STRUCTURE AND PROPERTIES OF SINTERED TITANIUM ALLOYED WITH MOLYBDENUM AND OXYGEN

Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 77 pp 39-43 manuscript received 25 Nov 75

SHIROKOVA, N. I., ANOKHIN, V. M. and OGNEV, R. K., Zaporozh'ye

Abstract The hardening effect of alloying titanium simultaneously with metals and refractory compounds (titanium oxide, zirconium oxide, and molybdenum) was studied. All the elements involved here form a wide range of solid solutions with titanium, which establishes the feasibility of solution-hardening both titanium modifications simultaneously. Microhardness tests were performed first on pure sintered titanium, then on titanium with oxides and titanium with up to 5% Mo, and finally on titanium-oxide-molybdenum composites microstructurally analogous to binary titanium-molybdenum alloys. The results of this study indicate that small additions of titanium and zirconium oxides raise the tensile strength of titanium to 85 kgf/mm<sup>2</sup> while reducing its plasticity. Alloying titanium with oxides and molybdenum raises the tensile strength to above 100 kgf/mm<sup>2</sup> without decreasing the plasticity below 8%. Figures 7; References: 7 Russian.

USSR

UDC 669.295:620.183

EFFECT OF CONDITIONS OF PRODUCING SODIUM-REDUCED TITANIUM POWDERS ON SOME OF THEIR PHYSICAL CHARACTERISTICS

Moscow IZVESTIYA AKADEMII NAUK SSSR, METALLY in Russian No 3, May-Jun 77 pp 31-35 manuscript received 26 Apr 76

ALEKSANDROVSKIY, S. V., SANDLER, R. A., KUZ'MENKO, A. S., BERDNIKOVA, L. M., and GOLIKOV, V. V., Leningrad

Abstract Titanium powders were produced on an experimental-production scale by reduction of molten titanium chlorides with pure metallic sodium at 850°C. Powder specimens were examined by various methods to determine the effect of the technological conditions such as the raw material, the preheat temperature, and the atmosphere on the specific surface, the grain size distribution, and the porosity of the product. The results of this

study confirm the feasibility of obtaining by this process titanium with a high yield of powder fractions. Under similar technological conditions, reduction of lower-valence titanium chlorides yields powders with a larger fine fraction, a lower porosity, and a smaller specific surface than powder obtained by reduction of titanium tetrachloride. Figures 1; References: 5 Russian.

USSR

UDC 621.762:669.295

PRODUCTION AND PROPERTIES OF THIN SHEET POROUS TITANIUM

Kiev POROSHKOVAYA METALLURGIYA in Russian No 6, Jun 77 pp 96-99  
manuscript received 28 May 76

TIKHONOV, G. F. and SOROKIN, V. K., Gor'kiy Polytechnical Institute

[Abstract] A study was made of the conditions of production, physical-mechanical and filtering properties of porous sheets of powders of calcium hydride titanium (types PTM and PTS) with the following content of impurities (mass %): 0.03 C, 0.05-0.06 Si, 0.13-0.21 Fe, 0.11-0.13 Ni, 0.05-0.07 N, 0.28-0.30 H, 0.03-0.08 Ca, 0.0030-0.0035 Cl. PTS powder has more large fractions than PTM. It is shown that a change in the granulometric composition of the powder influences the permeability factor and electric resistivity of the sheets. A comparative study is presented of the gas absorbing capacity of porous sheets of varying thickness of the two materials. It is found that additional annealing of the sheets in a vacuum increases the gas absorption capacity. It is shown that porous sheets of calcium hydride titanium powder have smaller pore diameters and better filtration properties and sheets of electrolytic titanium powder with equivalent porosity and thickness. Figures 3; References: 4 Russian.

USSR

UDC 621.762

STUDY OF FRICTION AND WEAR OF SINTERED TITANIUM MATERIALS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 6, Jun 77 pp 73-78 manuscript  
received 19 Dec 75

RADOMYSEL'SKIY, I. D., TITARENKO, S. V., PETROVA, A. M. and POLOTAY, V. V.,  
Institute of Problems of Material Science, Academy of Sciences UkrSSR

*[Abstract]* The purpose of this work was to determine the significance of structural factors (condition of matrix and presence of solid inclusions) in the suppression of plastic deformation of titanium and the corresponding process of seizure. Studies were performed on model specimens of the systems Ti-TiC, Ti-Cr, Ti-Cr-TiC, also using specimens of sintered unalloyed titanium for comparison. The specimens were produced by pressing and subsequent vacuum sintering of blanks of mixtures prepared using powders of electrolytic titanium in the fraction -0.18+0.04 mm and powders of chromium and titanium carbide of the fraction -10  $\mu$ m. Friction tests were performed in air using a shaft-ring system on an M-22M friction testing machine at sliding speeds of 0.5 to 6 m/s with pressures of 7 to 150 kg/cm<sup>2</sup>. The mechanism of the influence of hard inclusions (TiC) and the alloying element (Cr) on the behavior of titanium in friction differs. In Ti-Cr-TiC specimens, the titanium carbide prevents seizing of the material during the initial period of friction and with increasing pressure prevents development of plastic deformation in the volume of the material, helping to localize stresses in a narrow surface layer, while the chromium participates in the formation of surface wear-resistant structures with increasing temperature in the friction zone. Each of these factors acts in a limited sphere, under definite test conditions of pressure, temperature and speed, the simultaneous influence of both factors expanding the area of stable friction. Figures 3; References: 5 Russian.

USSR

UDC 621.762

CALCULATION OF THE OPTIMAL DIMENSIONS OF PRESS MOLD DIES WITH HARD ALLOY INSERTS FOR PRESSING OF POWDER PRODUCTS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 6, Jun 77 pp 15-21  
manuscript received 29 Apr 76

BABARITSKIY, K. A. and RADOMYSEL'SKIY, I. D., Brovary Powder Metallurgy Plant, Institute of Problems of Material Science, Academy of Sciences Ukr SSR

Abstract The short service lives of dies made from ordinary stamping steels has resulted in an ever increasing demand for press molds with inserts of hard alloy, which can increase the service life from  $10-15 \cdot 10^3$  products to  $400-500 \cdot 10^3$  products. Calculation of the optimal outside diameters of hard alloy inserts is a problem which can be basically reduced to determination of the optimal outside diameter of the hard alloy insert, its surrounding clamp and the interference of the fit. Formulas are presented for calculation of these characteristics. Figures 1; References: 11 Russian.

USSR

UDC 621.762.5

ELECTRIC DISCHARGE SINTERING OF MIXTURES OF COPPER AND ALUMINUM POWDERS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 77 pp 13-16 manuscript received 21 Dec 76

KOL'CHINSKIY, M. Z., MEDVEDENKO, N. F., SOLONIN, Yu. M., and GNATUSH, F. P., Institute of Problems of Material Science, Academy of Sciences UkrSSR

Abstract An experimental study was made of the regularities involved in the production of Al-Cu alloys by so-called electric-discharge sintering (EDC). The use of EDC alloys permits significant simplification of the technology of manufacture of alloys based on aluminum and other metals from mixtures of powders. The following powder mixtures were studied: I. Al-33 wt.% Cu; II. Al-5.7 wt.% Cu; III. Al-5.7 wt.% Cu. Alloy III was produced from a more coarsely dispersed powder than the other two. The sintering process involved preliminary compression of the powder; application of a pulsating current with an effective density of  $900 \text{ A/cm}^2$

with variable component frequency 2750 Hz; application of final pressure; cutoff of current and release of pressure. The total processing time was 25-95 sec. Homogeneous, high quality alloys are produced by reducing the first sintering pressure, thus reducing the sintering current at that point. The subsequent increase in pressure during the second pressurization stage increases the conductivity of the powder sintered and thus increases sintering current, producing alloys of homogeneous, high quality. Figures 3; References 11: 10 Russian, 1 Western.

USSR

UDC 621.762;669.715;539.2

INFLUENCE OF THE STRUCTURE OF SAP MATERIAL ON THE MUTUAL DIFFUSION WITH COPPER AT HIGH PRESSURES

Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 77 pp 17-21 manuscript received 22 Dec 75

SHINYAYEV, A. Ya., LITVINTSEV, A. I., and PIVKINA, O. G., All-Union Institute of Light Alloys

*[Abstract]* A study was made of the influence of the structural state of aluminum oxide in a sintered aluminum powder (SAP) material as it mutually diffuses with copper at normal and high pressures. The studies involved pure aluminum and SAP material (7%  $\text{Al}_2\text{O}_3$ ) with various structural states of the aluminum oxide. The studies were performed at 550°C (annealing 2 hours) and 640°C (annealing 1 hour) under normal and high (25 kbar) pressures. The coefficient of mutual diffusion of copper with the SAP material with plastic structure of the aluminum oxide is an order of magnitude less than with the diffusion pair including the SAP material with evenly distributed dispersed oxide phase formed after extrusion. Figures 3; References 9: 7 Russian, 2 Western.

USSR

UDC 621.669.27

STUDY OF THE INFLUENCE OF TITANIUM CARBIDE ON PROCESSES OF GRINDING,  
PRESSING AND SINTERING OF TUNGSTEN-MOLYBDENUM-VANADIUM STEEL POWDER

Kiev POROSHKOVAYA METALLURGIYA in Russian No 6, Jul 77 pp 22-26 manuscript  
received 29 Sep 76

KIPARISOV, S. S., PANOV, V. S., TRET'YAKOV, V. I., and SMIRNOVA, M. M.,  
Moscow Institute of Steels and Alloys

[Abstract] A study is made of the influence of the addition of titanium carbide (5-10 vol.%) on the process of grinding of chip waste of tungsten-molybdenum-vanadium steel (type R18), on the conditions of pressing and sintering of the powders produced, and the structure and properties of sintered blanks are studied. The initial material used was R18 steel chip and titanium carbide powder with a mean particle diameter of 2-3  $\mu$ m. Grinding was in hard alloy ball mills. It was found that the addition of titanium carbide powder had an intensifying effect on the process of grinding of the chips, helping to produce fine-grained (2.0-2.5  $\mu$ m), evenly distributed carbide grains. The introduction of titanium carbide increases the hardness of the high speed steel from HRC62 to HRC68. References:  
4 Russian.

USSR

UDC 64-419:661.666-426,669.718:539.4

STUDY OF THE INTERACTION OF CARBON FIBER WITH NICKEL THROUGH A DIFFUSION BARRIER OF ZIRCONIUM NITRIDE OR TITANIUM CARBIDE

Kiev POROSHKOVAYA METALLURGIYA in Russian No 6, Jul 77 pp 32-35 manuscript  
received 10 Aug 76

ZABOLOTSKIY, A. A., SALIBEKOV, S. Ye., KANTSEVICH, I. A., IGNATOVA, N. P.,  
and CHERNYAK, A. I., All-Union Scientific Research Institute of Aviation Materials

[Abstract] Initial carbonized carbon fiber with a strength of about 180 kg/mm<sup>2</sup> and a modulus of elasticity in extension of 22,000-25,000 kg/mm<sup>2</sup> was used, as well as the same fibers with a coating of zirconium nitride (zirconium content about 40 wt.%) and titanium carbide (titanium content about 6 wt.%). A layer of nickel 0.4-0.5  $\mu$ m thick was applied to the fibers

by a chemical method, after which the fibers were heat-treated in a vacuum of about  $10^{-3}$  mm Hg at temperatures between 600 and 1000°, times 1 to 50 hours. The carbon fibers in contact with nickel are greatly softened at temperatures over 600°C due to surface etching of the fibers by the nickel or recrystallization (at higher temperatures). Coatings of zirconium nitride are not an effective barrier in the interaction of carbon fibers with nickel. Coatings of titanium carbide slow the process of softening of the carbon fiber, even at high temperatures, decreasing the rate of dissolution of the carbon of the fiber in the nickel and delaying the process of recrystallization of the fibers. Figures 2; References 7: 3 Russian, 4 Western.

USSR

UDC 621.762:669.2/8

STUDY OF THE KINETICS OF SATURATION OF POROUS TITANIUM WITH MAGNESIUM

Kiev POROSHKOVAYA METALLURGIYA in Russian No 6, Jul 77 pp 51-55 manuscript received 14 Sep 75

FRANTSEVICH, I. N., KARPINOS, D. M., TUCHINSKIY, L. I., SAPOZHNIKOVA, A. B., and KLIMENKO, L. N., Institute of Problems of Material Science, Academy of Sciences UkrSSR

Abstract Results are presented from a study of the influence of porosity, pore diameter and temperature on the kinetic parameters of the process of saturation of porous titanium with magnesium and its alloys. The kinetics and optimal technological parameters of saturation of porous titanium briquettes with magnesium alloys was studied in order to establish an effective technology for the manufacture of new composite materials--titanium-magnesium pseudo-alloys. It is established that the saturation rate constant increases with increasing pore size with the same porosity and with increasing total porosity of the specimens. The rate of saturation is practically independent of temperature and type of magnesium alloys. The kinetics of saturation thus follow the main rules of the theory of capillary saturation. Figures 2; References: 11 Russian.

USSR

UDC 532.526.7

FRICITION AND WEAR OF BORON CARBIDE IN THE 20-1500°C TEMPERATURE RANGE

Kiev POROSHKOVAYA METALLURGIYA in Russian No 6, Jul 77 pp 60-63  
manuscript received 10 Sep 76

TKACHENKO, Yu. G., GRABCHUK, B. L., BODNARUK, N. I., and SYCHEV, V. V.,  
Institute of Problems of Material Science, Academy of Sciences UkrSSR

*[Abstract]* A study is made of the regularities of friction and wear of specimens of boron carbide produced by the method of pressing in metal press molds and subsequent sintering. The specimens are prepared of "pure" grade powder and technical grade boron carbide powder. The specimens contain excess carbon above the stoichiometric quantity ("pure" grade 23.4%, technical grade 24.9%, stoichiometric quantity 21.7%). Friction and wear testing was performed in a vacuum of  $10^{-5}$  mm Hg with a load of  $10 \text{ kg/cm}^2$  and a friction speed of 0.01 m/s. The tests indicate that technical boron carbide can be used as a wear-resistant material over a broad temperature range. The coefficient of friction decreases as temperature increases, wear intensity being maximum at 500°C. Figures 2; References 11: 9 Russian, 2 Western.

USSR

UDC 621.762

INTERACTION BETWEEN TITANIUM CARBIDE AND STEEL DURING SINTERING

Kiev POROSHKOVA METALLURGIYA in Russian No 8, Aug 77 pp 34-38 manuscript  
received 7 Jul 76

KIPARISOV, S. S., NARVA, V. K., LOSHKAREVA, N. S., and TITOV, A. V., Moscow  
Institute of Steel and Alloys

*[Abstract]* A study was made of alloys containing 10-40% TiC and 90-60% Kh6V3M steel as binder, after sintering and then annealing or quenching with subsequent tempering. Qualitative examination by microhardness testing and x-ray structural analysis of the crystal lattice as well as quantitative examination by chemical analysis and x-ray spectral analysis indicate an interaction between the two components and their redistribution as a result of sintering and heat treatment. Figures 2; References 6: 5 Russian, 1 Western.

USSR

UDC 621.762+543+669.018.4

STUDY OF THE DEGREE OF SURFACE FINISH OBTAINED BY SHOT BLASTING WITH  
TITANIUM CARBIDE AND SYNTHETIC DIAMOND MICROPOWDERS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 77 pp 89-91 manuscript  
received 26 Sep 76

PADERNO, V. N., MARTYNENKO, A. N., and GAYEVSKAYA, L. A., Institute of  
Problems of Material Science, Academy of Sciences UkrSSR

*[Abstract]* A study was made to determine the effectiveness of titanium carbide micropowder in abrasive finishing of technical-grade pure titanium and iron surfaces. Such surfaces were examined during shot blasting under an electron microscope rather than in polarized light because of the optical isotropy and opaqueness of carbide particles. A comparison with surfaces treated with synthetic diamond micropowder indicates that particles of titanium carbide, being smoother and more rounded, do not remain as firmly embedded in a surface and thus yield a smoother finish. Figures 3;  
References: 7 Russian.

USSR

UDC 677.546.2

STUDY OF THE OXIDIZABILITY OF CARBON FIBERS COATED WITH SILICON PYROCARBIDE

Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 77 pp 57-61 manuscript  
received 25 Sep 76

KILIN, V. S., CHEREDNIK, YE. M., LEBEDEV, YU. N., DERGUNOVA, V. S., and  
OSTROVSKIY, V. S., Moscow

*[Abstract]* Since the oxidizability of carbon fiber in air and in a carbon dioxide atmosphere can be reduced by an order of magnitude by a coating of silicon pyrocarbide, a study was made to evaluate the effect of the coating thickness and to determine the phase content in both an original and an oxidized fiber. Coatings 5+1, 50+5, and 100+10 nm thick were deposited on fiber specimens from the gaseous phase. Measurements revealed that the oxidation rate decreases with increasing coating thickness at all temperatures, regardless of the oxidizing agent, and that the activation energy of the C+CO<sub>2</sub> reaction (58 kcal/mole) as well as of the C+O<sub>2</sub> reaction (37

kcal/mole) is the same with or without coating. An x-ray structural analysis showed the presence of graphite and silicon carbide in an original fiber, silicon carbide and predominantly silicon oxide in an oxidized fiber. Figures 4; References: 4 Russian.

USSR

UDC 669.018.25

#### HARDNESS OF SINTERED TITANIUM DIBORIDE CERAMICS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 8, Aug 77 pp 48-50 manuscript received 25 Oct 74

GROPYANOV, V. M., KUZNETSOVA, V. L. and KLIMOVA, L. K., Leningrad Technological Institute imeni Lensovet

[Abstract] Pores in a sintered material play a dual role of decreasing the active cross section and thus increasing the stress concentration, on the one hand, while inhibiting the crack propagation and the dislocation movement so as to increase the strength. A study was made to determine the effect of porosity on the hardness of sintered titanium diboride ceramics, the hardness measured on the Rockwell A scale and the mean pore size established metallographically. As a result, the hardness has been found to increase exponentially with increasing porosity (vol %) but, at any given porosity level, to decrease linearly with increasing mean pore size. The hardness of specimens with a low porosity (1-4%) and a small pore size (3-4  $\mu$ m) was as high as 94-95 HRA 60. Figures 4; references 8: 7 Russian, 1 Western.

Steels

USSR

UDC 620.178.2:669.14.018.8

TEMPERATURE EMBRITTLEMENT OF STAINLESS MARAGING STEELS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 7, Jul 77 pp 24-26

IL'INA, V. P., KUZ'MINSKAYA, L. N., LAPIN, P. G., SPIRIDONOV, V. B. and FRIDMAN, V. S.

Abstract The purpose of this work was to determine the maximum temperature from which stainless maraging steel 03Kh11N10M2T2 (EP679), produced at the Novosibirsk Metallurgical Plant, can be slowly cooled and not suffer temperature embrittlement and to determine the minimum temperature and heating time necessary to remove temperature embrittlement if it cannot be avoided in the technological process. Different heat treating procedures were employed to obtain different grain structures and mechanical properties, from which it was determined that heating to 1100°C for one hour provides the desired absence of temperature embrittlement after slow cooling. The minimum temperatures to remove temperature embrittlement were 1000-1050°C with a 12-4 hour soak (in relation to temperature). Figures 3; references 6: 3 Russian, 3 Western.

USSR

UDC 669.112.227.34:539.26:669.15'71

REGULAR FEATURES OF LATTICE PARAMETER CHANGES IN AUSTENITE AND MARTENSITE OF ALUMINUM STEELS

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 43, No 2, Feb 77 pp 367-373 manuscript received 10 Aug 76 after correction

KRITSKAYA, V. K., IL'INA, V. A., and KORYTKINA, I. YA., Institute of Metal Studies and Physics of Metals of the Central Scientific Research Institute of Ferrous Metallurgy imeni I. P. Bardin

Abstract A study was made of the nature of changes in the crystal lattice of gamma and alpha phases of Fe-Al-C steels as a function of the concentration of carbon and aluminum in solid solution, and of the conditions for the gamma-to-alpha transition. Interest in such a study was occasioned by the recently observed anomalously high tetragonality of the martensite lattice of Fe-Al-C steels. There has as yet been no agreement on the reason for

this phenomenon. An explanation is essential for phase transformation theory. An x-ray structural analysis was made of alloys containing 3 to 10% Al and 1 to 1.8% C, which were chilled from 1200°C in water and then cooled in liquid nitrogen to obtain a martensite structure. The specimens were pickled to remove the decarbonized film. A determination was made of lattice parameters  $a$  and  $c$  by x-ray metallography, using a DRON-1 unit. It was found that the degree of tetragonality of the martensite lattice of Fe-Al-C steels is higher than in carbon steels with an identical carbon content, and that it is higher, the higher the concentration of aluminum in solid solution. The increase in tetragonality is associated not only with an increase in parameter  $c$ , but also with an anomalously great reduction in parameter  $a$ . A difference was found in the nature of interaction between carbon atoms and matrix atoms leading to different overall changes in carbon and aluminum steels, but the reason for this difference requires further study. A study was also made of the effect of heat treatment conditions on the state of Fe-Al-C austenite and martensite. For this purpose steel containing 7% Al and 1.8% C was smelted, the martensite point for this steel being lower than room temperature, making it possible to study the influence of various factors on the state of the austenite and the subsequent gamma-to-alpha transformation. Analysis of diffractograms demonstrated that the austenitic state depends to a strong degree on chilling temperature and conditions, on cooling rate, specifically. Measurements of austenite lattice parameter  $a$  showed that raising the chilling temperature results in a reduction of this parameter. It is concluded on the basis of the experimental data given here that the chilling temperature and rate have a quite substantial influence on the state of the high-temperature gamma phase and, with the subsequent gamma-to-alpha transformation, on the structure of the martensite and residual austenite. This influence is apparently a change in the degree of ordering of the initial austenite's lattice, and a change in the form and size of ordered regions and in the nature of their relationship to the matrix lattice. Figures 5; references 13: 5 Russian, 8 Western.

Thin Films

USSR

UDC 539.216.2:669.245'295

STUDY OF DIFFUSION PROCESSES IN AN Ni-Ti THIN FILM SYSTEM

Moscow FIZIKA I KHIMIYA OBRABOTKA MATERIALOV in Russian No 3, May-Jun 77  
pp 136-138 manuscript received 27 Oct 76

SHPURIK, V. N., SHALYGINA, N. A., DEGTYAREVA, L. Yu., MEL'NIK, I. G. and  
GERSHINSKIY, A. Ye., Novosibirsk

**[Abstract]** A study is made of diffusion in a thin-film Ni-Ti system, which is widely used in practice. Thin film specimens were produced by successive thermal evaporation of titanium and nickel in a vacuum of  $5 \cdot 10^{-6}$  mm Hg onto oxidized silicon substrates. The atomization temperature was 450°C, the time between applications of titanium and nickel 1.5 minutes. Isothermal annealing of specimens was performed in a temperature-controlled furnace at 400-525 C,  $5 \cdot 10^{-6}$  mm Hg. The process of diffusion was studied by an electrochemical method using an aqueous solution of 1%  $\text{NiF}_2$  and 0.1%  $\text{KFH}_2$ , which dissolves both metals, for electrochemical etching. The proportionality factors between the quantity of electricity and thickness of Ni and Ti are practically the same,  $140 \text{ A} \cdot \text{cm}^2/\text{coulomb}$ . The proportionality factors of the phases formed have the same value. Three intermetallic compounds are formed:  $\text{TiNi}_3$ ,  $\text{TiNi}$  and  $\text{Ti}_2\text{Ni}_3$ . The activation energy of consumption of nickel (2.26 eV) and of titanium (2.08 eV) are determined; the activation energy of the growth of the phases falls between the values of activation energy of consumption of nickel and of titanium. Changing the conditions of preparation of the specimens does not influence the activation energy, only changing the preexponential term. Figures 2; references 2: 1 Russian, 1 Western.

Titanium

USSR

UDC 669.295:536.63

TRUE THERMAL CAPACITY OF TS5 and VTZ-1 TITANIUM ALLOYS

Moscow IZVESTIYA AKADEMII NAUK SSSR, METALLY in Russian No 3, May-Jun 77  
pp 66-70 manuscript received 3 Sep 75

BELYAKOVA, P. YE., Moscow

*[Abstract]* High-strength titanium alloys are being more widely used in the production of steam turbines, mainly for blades, because of their good corrosion and wear characteristics. For engineering as well as scientific purposes, it is essential to know the thermophysical properties of such alloys. In this study the true thermal capacity ( $C_p$ ) of TS5 and VTZ-1 titanium alloys was measured over the 25-960°C temperature range by the calorimetric method with a continuous heat supply. Pre-annealed cylindrical specimens had been given various heat treatments so that the effect of the latter on these characteristics could be established. Figures 3; references 7: all Russian.

USSR

UDC 669.295:620.251.1:620.181.1

STUDY OF THE DECOMPOSITION KINETICS OF METASTABLE PHASES  $\alpha''$  AND  $\beta$  IN QUENCHED VTZ-1 ALLOY DURING TEMPER

Moscow IZVESTIYA AKADEMII NAUK SSSR, METALLY in Russian No 3, May-Jun 77  
pp 142-147 manuscript received 29 Oct 75

D'YAKOVA, M. A., L'VOVA, YE. A., KAGANOVICH, I. N., ZVEREVA, Z. F., and MESHCHANINOVA, L. S., Sverdlovsk

*[Abstract]* A study was made to determine how the phase composition of VTZ-1 titanium alloy as well as the decomposition kinetics of its metastable phases  $\alpha''$  and  $\beta$  are affected by the prequenching temperature and the subsequent temper range. Some specimens were quenched from 900°C and then tempered through 200-450°C; other specimens were quenched from 960 or 1000°C and then tempered through 300-400°C. On the basis of x-ray structural analysis, the transformations and the process kinetics were found to have been different in both cases. Figures 4; references 7: 6 Russian, 1 Western.

USSR

UDC 669:532.72

KINETICS OF HEAT LIBERATION DURING HIGH-TEMPERATURE NITRIDING OF TITANIUM

Moscow IZVESTIYA AKADEMII NAUK SSSR, METALLY in Russian No 3, May-Jun 77  
pp 178-181 manuscript received 2 Jul 75

KHARATYAN, S. L., GRIGOR'YEV, YU. M., and MERZHANOV, A. G., Moscow

Abstract A new electrothermographic method has been developed for studying fast diffusion processes where conventional methods fail. A special variant of this method was used to obtain data on the kinetics of heat liberation during nitriding of titanium at 1200-1600°C for 20-200  $\mu$ sec. An analytical evaluation of these measurements yields a kinetic equation of the exponential kind, and the constants in this equation, calculated from test data, are shown to depend neither on the surface curvature nor on the geometrical dimensions of the specimens. Figures 2; references 7: 5 Russian, 2 Western.

USSR

UDC 539.32:537.311.33

RECRYSTALLIZATION TEXTURE AND ANISOTROPY OF PROPERTIES OF COLD ROLLED  $\alpha$  TITANIUM

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 6, 1977 pp 71-73

BRYUKHANOV, A. A., IVANIY, V. S., VASYLIV, V. I. and MOROZ, I. A.

Abstract A study was made of the influence of annealing on the texture and changes in elasticity modulus, resistivity and thermal emf of sheets of VT1-1  $\alpha$  titanium rolled at room temperature with 10-80% compression. Rectangular specimens, cut at various angles to the rolling direction, were mechanically and chemically polished, then annealed in a vacuum for 1 hr and cooled with the furnace. Annealing was performed at intervals of 50°C in the 100-850°C range. Annealing of titanium sheets causes restructuring of the crystallographic structure, relieving internal stresses and resulting in both primary and secondary recrystallization, which may change the absolute value of the quantities measured as well as their relationships in various directions in the sheet. At annealing temperatures of up to 500°C,

the texture of cold-rolled sheets does not undergo significant changes. The anisotropy of the properties remains the same as for the original cold-rolled sheets. In the area of higher temperatures, in addition to changes in the absolute values of E,  $\sigma$  and temf, there is a significant change in their anisotropy. Thus, after annealing at 800°C, the degree of elastic anisotropy is 7% as opposed to 12.5%, the temf and resistivity show anisotropies of less than 3 and 4% as opposed to 3 to 8% and 2.5 to 4% respectively, regardless of the degree of compression of the cold rolling. Figures 3; references 7: 5 Russian, 2 Western.

USSR

UDC 546.56.181.1

#### INTERACTION OF TITANIUM WITH PHOSPHORUS AT HIGH TEMPERATURES

Moscow IZVESTIYA AKADEMII NAUK SSSR. NEORGANICHESKIYE MATERIALY in Russian  
Vol 13, No 6, Jun 77 pp 1086-1087 manuscript received 22 Dec 75

UGAY, Ya. A., ILLARIONOV, A. A., GUKOV, O. Ya. and DOROKHIN, S. M.,  
Voronezh State University

[Abstract] A study is made of the kinetics of interaction of plates of metallic Ti with phosphorus vapors at high temperatures. The kinetics of interaction of Ti with P were studied by the method of continuous weighing. A plate of iodide Ti was placed together with B5 phosphorus at different ends of a quartz ampule, which was then evacuated to  $10^{-4}$  mm Hg, sealed and placed in a two-zone furnace, rigidly connected to one arm of an analytic balance. The equilibrium vapor pressure of phosphorus in all series of experiments was 1 atm. Weight changes were recorded each 30 minutes; total experimental time was 15 hours. X-ray phase analysis showed that in all cases, TiP was formed on the surfaces of the plates. The rate of growth of the phosphide layer decreased at temperatures over 1000°C; at about 1000°C, the phosphide layer on the Ti cracks, losing its protective properties, produced a linear dependence of TiP formation rate. Above 1000°C, the damaged layer is resintered and diffusion control of the reaction between Ti and P is reestablished. Figures 2; references 3: all Russian.

Welding

USSR

UDC 621.791.001.5:669.785:620.18

MECHANISM OF FORMATION OF GAS BUBBLES IN THE WELDING BATH DURING WELDING OF ACTIVE METALS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 77 pp 53-57

*[Abstract]* Based on thermodynamic analysis, an experimental mechanism for the formation of gas bubbles in the welding bath of active metals is suggested and confirmed. The main condition for the formation of gas bubbles in the welding bath is the existence on the surface of the ends of the welded edges or the welding wire of various defects and the presence in their volume of adsorbed gases, water vapor and contaminants which may decompose as they are heated to form gases poorly soluble in the liquid metal. It is shown that the main source of gas forming bubbles in the welding bath is moisture which is adsorbed or condensed in capillary pores in defects on the end surface of the welded edges and welding wire. Figures 4; references 17: all Russian.

USSR

UDC 621.791.4.01:539.378.3

USE OF HOLLOW CATHODE WITH EMISSION COATING OF INTERNAL SURFACE FOR WELDING IN A VACUUM

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 77 pp 35-36

KRYUKOVSKIY, V. N., IL'INSKIY, A. M., YEVGRAFOV, N. N., LAKINA, T. A., and KLIMOV, V. V.

*[Abstract]* The purpose of the present work was to develop a coating for the internal surface of a cathode which would allow making it possible to achieve the same values of welding current as are produced by an uncoated cathode, but at a lower operating temperature. The emission properties of the coatings tested were evaluated on the basis of a method involving measurement of current at reduced cathode temperatures by brief quenching of the arc by stopping the argon feed into the cathode cavity. An emission coating for the internal surface of the cathode was developed, allowing the operating life of the cathode to be increased significantly by decreasing the temperature in the active zone of the cathode by 350-400°C and also

decreasing the discharge excitation voltage. The optimal composition of the emission coating was (wt.%): LaB<sub>6</sub> 40-70, Cs<sub>2</sub>CrO<sub>4</sub> 20-50, KLaW<sub>4</sub> 10. Figures 3; references 4: all Russian.

USSR

UDC 621.791.052.01:620.192.4

KINETICS OF CRACK DEVELOPMENT UPON CYCLIC LOADING OF WELDED AND GLUED-WELDED JOINTS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 77 pp 2-4

RYAZANTSEV, V. I., candidate of technical sciences, SHAVYRIN, V. N., candidate of technical sciences and LYUBITSKIY, T. T., engineer

*[Abstract]* A study is made of the crack growth rate in specimens as a function of type of joint, type of material, method of surface preparation and test conditions. In glued-welded specimens of D16T alloy, the crack growth rate is less than half the crack growth rate in the base metal and less than one-third that in welded joints. The crack growth rate is practically the same for welded and glued-welded joints of OT4-1 alloy tested in air. There is a clear bend in the curves showing crack length as a function of number of loading cycles for welded and glued-welded joints, corresponding to the movement of the crack into the zone of the welded spot. The time of the bend is determined by the type of alloy, type of joint, shape of specimen and test conditions. When tested in a 3% NaCl solution, crack growth rates in the base metal of D16T are 2.25-2.5 times higher, and for OT4-1 specimens 6.2-6.8 times higher than in air. The influence of corrosion is noticeably less in the joints than in the base metal. The crack growth rate is significantly lower in anodized specimens. Figures 5; references 8: all Russian.

USSR

UDC 621.791.011:669.14.018.8

WELDABILITY OF FERRITIC CHROMIUM STAINLESS STEEL CONTAINING TITANIUM AND VANADIUM

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 7, Jul 77 pp 28-30

ODESSKIY, D. A., candidate of technical sciences (deceased), VOZDVIZHENSKIY, V. M., doctor of technical sciences, and LIVANOVA, R. P. and POSTNOVA, A. D., engineers

Abstract A chromium stainless steel--OKh18F2T1 (Author's Certificate No. 416411)--was developed which has better resistance to intercrystalline corrosion by the addition of small amounts of titanium and a stable ferrite by the addition of vanadium. In testing the weldability of this new steel, using welding rods of OKh18N9 and 04Kh18N11M3 (EI400) steels, it was found that mechanical properties close to those of the base metal could be achieved if the proper welding mode were employed. The best welding modes were found to be argon-arc and resistance welding despite the slight growth in ferrite grain size. When these processes are used there is no embrittlement of the heat-affected zone due to phase transformations in the ferrite solid solution. Thus, OKh18F2T1 steel can be employed successfully in a number of cases as a substitute for type 18-8 chromium-nickel steels. Figures 3; references: 1 Russian.

USSR

UDC 621.791.052:621.791.011:669.715

EFFECT OF ANNEALING MODES ON RESIDUAL STRESSES IN WELD JOINTS OF MA12 ALLOY

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 7, Jul 77 pp 22-24

POPOV, A.S., candidate of technical sciences and OSOKINA, T. N., KARAN, A. B. and ZHELOBTSOV, Ye. A., engineers

Abstract Since in recent tests it has been determined that MA12 magnesium alloy fails under pressure, a study was made to find the effect of annealing modes on the level of residual welding stresses and weld joint strength of this alloy. It was found that residual stresses which form in the weld joints depend on the initial thermal state which are

maximum in the hardened ( $11 \text{ kgf/mm}^2$ ) and minimum in the annealed ( $5 \text{ kgf/mm}^2$ ) state. In the hardened-plus-aged state these stresses amount to  $8 \text{ kgf/mm}^2$ . The maximum longitudinal residual stresses can be reduced to  $5-6 \text{ kgf/mm}^2$ , independent of initial thermal state, by annealing MA12 weld joints at  $250^\circ\text{C}$  for 2-3 hours. By annealing at  $350^\circ\text{C}$  for 1-1.5 hours these stresses are reduced to  $2-3 \text{ kgf/mm}^2$ . To increase the strength of MA12 weld joints it is necessary to remove the residual stresses; however this can result in a strength loss to the basic material and means must be found for removing local residual stresses in the weld joint by, for example, induction or beam-source heating. Figures 5; references 3: all Russian.

USSR

UDC 621.791.053.011:669.14.018.44

#### SEAM METAL DUCTILITY IN THE CRYSTALLIZATION PROCESS IN WELDING HIGH-TEMPERATURE MATERIALS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 7, Jul 77 pp 8-10

SLAVIN, G. A., candidate of technical sciences and MOROZOVA, T. V., engineer

[Abstract] The effect of welding method and mode and seam metal structure on the deformation capacity (ductility reserve) and deformation kinetics, found in the temperature interval of brittleness, was studied in the welding of high-temperature homogeneous materials EI835, VZh-98 and EI435. The effect of welding modes, providing transcrystalline and axial-crystalline structures, on the ductility reserve of the seam metal during crystallization was studied using high-speed photography. Inclusion heterogeneity was established for the process of deformation of sections of the seam metal positioned at various distances from the seam metal axis. Deformation is localized in some zone of the seam and the magnitude of this deformation is dependent on the type of crystal structure. Thus, the ductility reserve of the metal depends on the seam metal structure, and seams possessing a structure with axial crystallites have the highest ductility reserve. Figures 8; references 3: all Russian.

USSR

UDC 621.791.4:539.378.3:669.14.018.295

DIFFUSION WELDING OF HIGHLY POROUS MATERIALS

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 7, Jul 77 pp 14-15

KAZAKOV, N. F., doctor of technical sciences, SOLUYANOVA, Ye. K., engineer, and SHIBRYAYEV, B. F., doctor of technical sciences

[Abstract] Tests were conducted to determine the optimum temperature of weld joint heating, optimum pressure during heating and the optimum time for soaking or holding these conditions in the process of diffusion welding of 1Kh18N9 powdered stainless steel with a porosity of almost 40%. The optimum parameters were found to be 1200°C for 60 seconds under a pressure of 0.2-0.3 kgf/mm<sup>2</sup>. Higher pressures and temperatures reduced porosity and increased weld zone strength. Figures 4; references 3: all Russian.

Miscellaneous

USSR

UDC 669.017:541.1+669.295+669.292

CONCERNING THE SOLUBILITY OF VANADIUM IN ALPHA-TITANIUM

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 8,  
1977 pp 60-61

MOLOKANOV, V. V., CHERNOV, D. B., BUDBERG, P. B., Institute of Metallurgy  
imeni A. A. Baykov

*[Abstract]* In order to refine the available information on the solubility of vanadium in alpha-titanium, its solubility was determined using materials of high purity over a broader temperature range than in earlier studies. The results of the studies were used to construct a solubility curve of vanadium in alpha-titanium. The position of this curve up to 600°C coincides with the position of the solubility curve determined in an earlier American work and also agrees well with the calculated data. The experimental and calculated data agree well throughout the entire temperature range studied (400-700°C). The experimental curve of solubility is clearly retrograde. As the temperature drops from the point of polymorphous conversion to 550°C, the solubility increases to about 4%. Further decreases in temperature cause solubility to decrease, to not over 2.5% at 400°C. Figures 3; references 5: 3 Russian, 2 Western.

USSR

UDC 621.791.92:669.018.9

SURFACING OF COMPOSITE ALLOYS (REELITE + MANGANESE MELCHIOR) USING THE AUTOVACUUM EFFECT

Moscow SVAROCHNOYE PROIZVODSTVO in Russian No 8, Aug 77 pp 21-23

KUDINOV, V. D., FILIMONOV, B. V., STEPANOV, B. V., SOLOMATIN, V. Ye.,  
DUDKO, D. A., MAKSIMOVICH, B. I., and NETESA, N. V.

*[Abstract]* The charging device of a blast furnace with a volume of 5000 m<sup>3</sup> was strengthened by facing the parts of the liner elements with a composite alloy. The surfacing technology was developed by the Institute of Electric Welding imeni Ye. O. Paton and Uralmashzavod. The pipes were surfaced in the vertical position using a special device for this purpose. Saturation of tungsten carbides placed in the pipes with the binder alloy was performed from the top (20 pipes simultaneously from a common

container). The autovacuum effect was used to draw the liquid binder alloy up into the cavity from a bath below the pipes. Direct measurements on the experimental parts showed that, depending on the heat treatment mode, the residual pressure in the surfaced cavity varies from 140 to 585 mm Hg, while the metal-binder combination rises to 920-1520 mm in the pipes.

Figures 4; references 9: all Russian.

USSR

UDC 621.762

#### PRODUCTION AND PROPERTIES OF TYPE 5 IN PERMALLOY

Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 77 pp 6-10 manuscript received 5 Jan 76

KOROBOVA, T. A., RUKIN, V. V., DZNELADZE, Zh. I., KRUCHININA, S. F., and KASPARYAN, R. M., Central Scientific Research Institute for Ferrous Metallurgy

[Abstract] The Central Scientific Research Institute for Ferrous Metallurgy has developed a technology for the production of metals and alloys of chemically pure chlorides. The initial raw material is any nickel-containing material, for example nickel dross, ferronickel, etc., which is leached in hydrochloric acid, crystallized as the binary salt  $(Fe,Ni)Cl_2 \times 4H_2O$  and reduced in hydrogen at 450-600°C. The sponge thus produced is a homogeneous alloy. X-ray structural analysis indicates that there is a single-phase area of  $\gamma$  solid solution with a lattice period of  $a=2.8347$  Å. The sponge is ground in a ball mill, pressed into blanks weighing from 1 to 5 kg on a hydrostatic press at 900 atm. gage ( $0.9$  t/cm $^2$ ) and sintered in dry hydrogen (dew point -50°C) at 600°C for 5 hr, then at 900°C for 5 hr, at 1300°C for 5 hr, the intermediate holding temperatures intended to burn off carbon and oxygen, respectively. The density of the specimens after sintering is 92-97%; the content of individual impurities is: carbon 0.003%, sulfur 0.001%, oxygen 0.01%. Wire produced from the permalloy thus produced has higher and more stable mechanical and magnetic characteristics than ordinary wire.

Figures 3; references 11: all Russian.

USSR

UDC 546.719.661:685:669.78

CHEMICAL PROPERTIES OF RHENIUM SILICIDES AND GERMANIDE

Kiev POROSHKOVAYA METALLURGIYA in Russian No 7, Jul 77 pp 1-5 manuscript received 17 May 76

POPOVA, O. I., Institute of Problems of Material Science, Academy of Sciences UkrSSR

Abstract A study is presented of the chemical stability of rhenium silicides and germanide in relationship to certain corrosive media and the oxygen of the air. Specimens were produced by arc melting of the initial components and were identified by chemical and x-ray phase analysis. The work utilized specimens ground and screened through a screen with a nominal aperture diameter of 0.040 mm. Chemical resistance was studied by the usual method. A table presents the rate of oxidation of rhenium, rhenium germanide and rhemium silicides, as well as the chemical stability of rhenium silicides and germanide in hydrochloric acid, sulfuric acid, nitric acid, hydrofluoric acid, phosphoric acid,  $H_2C_2O_4$ , ammonium fluoride, hydrogen peroxide, bromine and sodium hydroxide. References 7: 6 Russian, 1 Western.

USSR

UDC 669.15-192:620.171.3

PROPERTIES OF EUTECTIC ALLOYS CONTAINING TITANIUM DIBORIDE AT HIGH TEMPERATURES

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 8, 1977 pp 53-55

SHURIN, A. K., PANARIN, V. Ye., SUL'ZHENKO, V. K., KOZYRSKIY, G. Ya., Institute of Metal Physics, Academy of Sciences UkrSSR

Abstract One progressive method of producing heat resistant materials is the creation of metal-based composites reinforced with refractory high-strength fibers or plates. Eutectic alloys consisting of a metal plus an interstitial phase are natural composites which have chemical compatibility and strong bonding between matrix and fibers. The eutectic alloys Fe-TiB<sub>2</sub> and 12Kh18N9T steel-TiB<sub>2</sub> have high strength at room temperature and at temperatures up to 1000°C, and high wear resistance under conditions of dry

sliding friction. Furthermore, the eutectic alloy 12Kh18N9T-TiB<sub>2</sub> has relatively high corrosion resistance and good high temperature strength at up to 550°C. Figures 4; references 4: 3 Russian, 1 Eastern European.

USSR

UDC 669.539.219.3

TECHNOLOGICAL STRENGTH AND NONDESTRUCTIVE METHODS OF TESTING DURING HEAT TREATMENT

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 8, 1977 pp 33-35

KRISHTAL, M. A., Tol'yatti Polytechnical Institute

*[Abstract]* The "technological strength" of a material considers both the numerical values of mechanical characteristics of the material and the structural peculiarities of the material, for example structural defects in the material after technological treatment such as heat treatment. It is therefore a more realistic term than ultimate strength for calculation of the actual reliability and usage characteristics of materials. Several examples are analyzed, illustrating the relationship between technology, heat treatment and chemical treatment and the resulting technological strength. Several methods of nondestructive testing are analyzed: measurement of internal friction by determining the rate of attenuation of oscillations in parts of complex shape; determination of the modulus of elasticity; and determination of density. A special section discusses emission methods, such as measurement of exoelectron and acoustical emissions. References 2: both Russian.

NEW APPROACH TO DETERMINING THE ACTIVATION ENERGY OF HIGH-TEMPERATURE  
STEADY-STATE CREEP

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 43, No 2,  
Feb 77 pp 388-397 manuscript received 24 Mar 76

MOVCHAN, B. A., and NERODENKO, L. M., Institute of Electric Welding imeni  
Ye. O. Paton of the Academy of Sciences USSR

[Abstract] A new approach is taken to determine the activation energy of high-temperature steady-state creep in metals by analyzing a structural phenomenological model of solid-state plastic deformation. Existing methods of calculating this characteristic are analyzed. It is ordinarily determined by analyzing the change in rate of steady-state creep as a function of a change in effective stress and temperature. Formulas usually used for calculating rates of steady-state creep in the  $10^{-3}$  to  $10^1$  percent-per-hour range are given, and it is pointed out that the values used for the activation energy in these formulas differ widely in the case of pure metals. These values are presently considered conditional or effective activation energy values and are equated with the activation energy for self-diffusion of atoms in the metal's crystal lattice in some studies. Lack of agreement between values obtained experimentally and by calculation using these formulas, in the case of pure metals, has led to emended formulas, which take into account the strain of "friction" in the crystal lattice caused by the presence of dissolved atoms, dispersed particles and dislocations. Based on a statistical analysis of experimental data on multiplication of dislocations under the effect of an applied stress and on an analysis of high-temperature creep from the viewpoint of elementary processes of plastic deformation and recovery, a formula has been derived which takes into account the lower and mean values of the microscopic elastic limit, i.e., the stress giving rise to the origin of movement and the multiplication of dislocations. It has been demonstrated that the mean value of the microscopic elastic limit is a function of the activation energy, as well as of temperature. A determination was made of the mean value of the microscopic elastic limit and of the activation energy for creep for a number of pure metals and solid solutions by graphic analysis of experimental data gathered by the authors and available in published sources. It was found that the values for the activation energy for high-temperature creep in pure metals arrived at in this study are close to values obtained for the migration energy of vacancies. The approach used here makes it possible to explain conflicting data sometimes obtained in terms of concentration of vacancies and self-diffusion and other processes. Figures 6; references 54: 26 Russian, 2 Czech, 1 Polish, 25 Western.

## RELATIONSHIP BETWEEN SCALE AND HARDNESS

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 43, No 2,  
Feb 77 pp 374-379 manuscript received 30 Mar 76

SHORSHOROV, M. KH., ALEKHIN, V. P., and BULYCHEV, S. I., Institute of  
Metallurgy imeni A. A. Baykov of the Academy of Sciences USSR

[Abstract] There has been no clear-cut physical model making it possible to give a quantitative description of the relationship between micro-hardness and the dimensions of a pyramidal or conic indenter, and this has hindered practical employment of the indentation method for evaluating the physical and mechanical properties of materials. This paper discusses a model of the relationship between scale and hardness which takes into account both the diminishing field of stresses and the nature of the process of strain hardening of a material with an indenter. This process involves the fact that diminishing dislocation density takes place beneath the indenter owing to the angle of the indenter's point and the type of strain hardening curve for the original material, in conformity with the diminishing stress field. This means that the strain hardening process is developed to a maximum in the layer of the material directly touching the indenter and that it is exactly this focal point of strain which chiefly determines the hardness value. Interaction between dislocations at this focal point leads to the formation of a whole range of numerous strong and weak detainers ordinarily considered in strain hardening theory. The model discussed here begins with the quasi-static nature of the indentation process and in more general form takes into account the relationship between the dimensions of the indenter and the distribution density of flaws in the layer of material dealt with. The concept of hardness is defined here as a structure-sensitive characteristic of a material, and its magnitude is a function of the contribution of effective shear stress (created in the material by application of the indenter), the temperature, the magnitude of average strain, and the true rate of straining during indentation. The relationship between scale and hardness is considered in this paper under conditions of the magnitude of average strain and the temperature remaining constant. Furthermore, the contribution of the effective shear stress is disregarded. The magnitude of average strain during indentation was determined by constantly measuring the depth of the indenter. It is demonstrated that under conditions of a diminishing field of stresses beneath the indenter the hardness function is determined by the average distance between detainers (stationary and sessile dislocations, precipitation particles, and the like). Generally this distance depends on the dimensions of the indenter and gives

rise to great diversity among hardness functions. The concept of average true rate of straining during indentation is introduced in this paper for the first time. Taking this condition into account makes it possible to achieve good agreement between experimental and calculated values. The model suggested here is applicable in the range of comparatively large indenter dimensions; other factors must be taken into account in the sub-microhardness region. The microhardness function arrived at here makes it possible to evaluate the structural state of a material beneath an indenter and to make a more reliable correlation between micro- and macrohardness values. Figures 2; references 9: all Russian.

USSR

UDC 669.017:53+669.74

#### EFFECT OF SHAPE MEMORY IN MANGANESE-NICKEL ALLOYS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 234, No 6, 21 Jun 77  
pp 1309-1312 submitted for publication 5 Jan 77

VINTAYKIN, YE. Z., UDOVENKO, V. A. and GOGUA, L. D., Institute of Metal Studies and Physics of Metals, Central Scientific Research Institute imeni I. P. Bardin, Moscow

Abstract Three Mn-Ni alloys: 1) 83.8, 2) 85.0 and 3) 86.13% Mn, which are face-centered-cubic (FCC) above the martensite transformation temperature ( $T_M$ ) and face-centered-tetragonal (FCT) below it, were studied to observe the features of the martensite transformation and the effect of these features on the mechanical phenomenon of "shape memory". Alloy 1 transforms from a FCC to a FCT structure with a lattice parameter ratio  $c/a > 1$ , while the  $c/a$  ratio is greater than one for alloy 3; alloy 2 transforms to a rhombic structure. Each alloy exhibited different degrees of shape recovery after heating and cooling, but as subsequent heatings were conducted the degree of recovery became more constant and the paths on strain-temperature curves became more identical. Alloy 2 gave the most constant results and explanation of the "shape memory" phenomenon could be explained to the point that the initial deformation at room temperature occurred in a state where the sample structure was close to tetragonal with  $c/a > 1$ . This deformation was accomplished by two means: twinning in favorably oriented grains and conventional slip of close-packed planes in the other grains, providing minimum internal stresses. Upon heating above  $T_M$  the twinning deformation was eliminated, thus allowing crystal shape

recovery. This process was accompanied by formation of uncompensated directed internal stresses in the alloy due to the presence of regions deformed by slip. With subsequent heating and cooling, a domain structure was formed at point  $T_M$  under the influence of these stresses which provided the best compensation of the directed internal stresses. Figures 2; references 5: 4 Russian, 1 Japanese.

USSR

UDC 669.15:548.526:620.187.3

STRUCTURAL HEREDITY MECHANISM IN HYPEREUTECTOID STEELS WITH AN ORIGINAL PERLITE STRUCTURE

Sverdlovsk FIZIKA METALLOV I METALLOVEDENIYE in Russian Vol 43, No 2, Feb 77 pp 358-366 manuscript received 2 Jun 76

SCHASTLIVTSEV, V. M., and YAKOVLEVA, I. L., Institute of Metal Physics of the Ural Scientific Center of the Academy of Sciences USSR

Abstract The purpose of this paper is to find an explanation for the phenomenon of structural heredity observed when heating hypereutectoid steels with an initial perlite structure. The term structural heredity means that newly formed austenite grains display an orientational relationship to the original grains and is explained by the fact that in hardened steel the alpha phase within the boundaries of each grain is orientationally related to the initial austenite, and with renewed heating the formation of austenite occurs according to an orderly mechanism. This paper seeks an explanation of this mechanism. Electron microscope and x-ray structural studies were made of the structure of 120G4 and U15 hypereutectoid steels (respective composition: 1.12% C, 4.25% Mn, 0.28% Si; and 1.49% C, 0.55% Si). Austenite formation was studied in specimens with a perlite structure heated to 650 to 1000°C and cooled in water. A Tesla BS-613 electron microscope was used for structural analysis and an RKS-2 camera for x-ray analysis. The structural heredity mechanism suggested for the case of coarse-grained hypereutectoid steels with a perlite structure explains restoration of the austenite grain with repeated heating. It is demonstrated that, in hyper-eutectoid steels, when perlite nucleation occurs through Widmanstätten carbides separated from the austenite and orientationally related to it, an oriented perlite structure forms. The ferrite component of this perlite is related to the austenite. Thus are created the preconditions for the phenomenon of structural heredity when heating takes place. It is

demonstrated further that, when steel with an oriented perlite structure is heated, preferred austenite nucleation takes place and that growth occurs more rapidly in the vicinity of Widmanstätten carbides, to which the austenite is orientationally related. This leads to the appearance of large austenite grains within the boundaries of the initial grain, whose orientation concurs with the orientation of the initial austenite grain. With further heating they merge, absorbing fine disoriented austenite grains which originate in place of the perlite, which in turn results in restoration of the grain in size, shape, and crystallographic orientation. The restored grain has more flaws than the original and recrystallizes with further heating. It is emphasized that the phenomenon of structural heredity in steels which have undergone perlite transformation is not a distinctive feature of manganese steels alone, for restoration of the grain with subsequent heating is also observed in carbon steel (U15) having a perlite structure with excess Widmanstätten carbides, after isothermal transformation. Figures 7; references 12: 6 Russian, 6 Western.

USSR

UDC 669.295:621.774.372

#### COLD ROLLING OF VT1 ALLOY PIPE

Moscow TSVETNYYE METALLY in Russian No 5, May 77 pp 60-61

SOKOLOVSKIY, V. I., BAZHANOV, Yu. M., (deceased), SMIRNOV, V. G.,  
SMIRNOV, V. A. and DOMNIN, I. I.

[Abstract] Several batches of pipe were manufactured from VT1-0 titanium alloy using a zinc diffusion coating applied to the non-annealed blanks after the first rolling and grinding of the outer surface. A decrease in free reduction was achieved by manufacturing pipes of moderate diameter with high accuracy of inside diameter, by using mandrels with cylindrical gauge sections 0.2-0.5 mm smaller in diameter than the gauge section of the mandrel used in the previous rolling pass, thus decreasing the degree of free reduction from 1-2 to 0.1-0.2 mm. The use of this method of working with the zinc coating made it possible to eliminate two or three intermediate annealing cycles and a number of other operations while increasing the yield of usable finished products by 5.3% in one batch, 2.3% in another.

USSR

UDC 669.017.3:669.14.018.44

TEMPERATURE OF DISSOLUTION OF HARDENING INTERMETALLIC PHASES IN HEAT-RESISTANT NICKEL ALLOYS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 6, 1977 pp 67-68

LOGUNOV, A. V., PETRUSHIN, N. V. and KHATSINSKAYA, I. M., All-Union Scientific Research Institute of Aviation Materials

*[Abstract]* In this work, the electric resistance and dilatometry methods, which directly characterize the condition of alloys when exposed to high temperatures, were used to determine the temperature of full dissolution of the  $\gamma'$  phase in nickel-based high-temperature alloys. Comparison of the results produced showed that the temperature of full dissolution of the  $\gamma'$  phase as determined by measurements of resistivity and dilatometry differed by not more than  $\pm 10^{\circ}\text{C}$  and agreed well with the data of phase analysis and electron microscopy. The temperature of full dissolution of the hardening phase depends on the total content of alloying elements in the alloy, the content of  $\gamma$  and  $\gamma'$  phases, as well as the total content of  $\gamma'$ -forming elements (Al, Ti). The maximum temperature of full dissolution is achieved with a total content of alloying elements of about 40 at.%, in the  $\gamma$  and  $\gamma'$  phases--45 and 33 at.% respectively. Figures 2; references 6: all Russian.

USSR

UDC 620.169.1:620.178.3:669.141.31

INFLUENCE OF THE PARAMETERS OF THE CASE-HARDENED LAYER ON THE PROPERTIES OF 20Kh3MVFA STEEL

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 6, 1977 pp 57-61

UTKINA, A. N., CHERKIS, Yu. Yu. and ALEKSEYENKO, M. F., All-Union Scientific Research Institute of Aviation Materials

*[Abstract]* A study is made of the influence of the structure, phase composition of the surface layer and concentration of carbon in the surface layer on the contact durability and fatigue strength in bending of 20Kh3MVFA and 12Kh2N4A steels. Contact durability was determined on a type

Sh-17 two-contact roller machine under test conditions similar to the contact conditions encountered in gears, with specific slip 0.065 m/s. Endurance was determined on type MVP-10,000 machines in pure bending with rotation with a test duration of  $2 \cdot 10^7$  cycles. The 20Kh3MVFA steel was case hardened in an endothermic atmosphere of propane-butane at 930°C, dew point of gas -15°C, holding time 5 hours, producing a case-hardened layer 1.1-1.2 mm in thickness with a carbon concentration of 1.2-1.3%. This was followed by tempering at 650°C, hardening from 900°C, cold treatment at -70°C, 2 hr, tempering at 300°C, 3 hr, or hardening from the case-hardening heating, cold treatment at -70°C, tempering at 300°C, 3 hr. The 12Kh2N4A steel was case hardened to a depth of 1.1-1.2 mm in an endothermic atmosphere at 920°C, dew point -5 to -10°C, carbon concentration on surface 0.9-1.4%, which was followed by tempering at 650°C 6 hr, hardening from 800°C, cold treatment at -70°C, 2 hr, tempering at 160°C, 3 hr. It was found that the optimal carbon concentration is 1.3-1.5% for 20Kh3MVFA steel, 1.0-1.2% for 12Kh2N4A steel, producing the maximum durability. Quenching from the cementation heating, with no long high tempering, the higher hardening temperature and greater cooling rate helped to increase the content of carbon and alloying element in the solid solution, increasing the contact durability of the steel. Residual austenite in the case-hardened layer is not permissible for highly stressed parts. The optimal structure is finely dispersed martensite with fine globular carbides at a depth of 0.15-0.25 mm (after grinding 0.2 mm off each side). Figures 3; references 3: all Russian.

USSR

UDC 669.15-194.3:621.791.053:543.423.063

USE OF THE IMA-1 LASER MICROANALYZER TO STUDY WELDED SEAMS OF HIGH ALLOY STEELS

Moscow ZAVODSKAYA LABORATORIYA in Russian Vol 43, No 4, 1977 pp 445-448  
manuscript received 22 Dec 75

MAKSIMOV, D. YE., RUDNEVSKIY, N. K., RYABCHIKOVA, V. P., CHEKHONIN, S. M., SHLYAPNIKOV, I. V. and SHKLYAYEVA, I. S., Institute of Chemistry of Gor'kiy University

Abstract A quantitative microspectral study was made of the distribution of the basic alloying elements Cr, Ni, Mn, Si and Ti in the cross-section of welded seams of type 10Kh20N7T steel. The IMA-1 laser microanalyzer produced by the Zeiss company in East Germany was used with a type ZFL-1000 neodymium rod laser pumped by a Soviet type IFP-1200 flash tube. The object

of the microspectral study was the welded seam from the transition zone to the center of the seam. Curves of the distribution of elements are presented. The studies provide a partial answer to the question of the cause of crack formation in welded joints, thus allowing an improvement in welding technology. In the studies in question, in which the base metal was chrome-nickel-molybdenum steel, and the metal of the welded seam consisted of chrome-nickel-titanium steel, the structure of the base metal is martensitic, and that of the welding wire--austenitic. After welding, at the boundary of the seam and the base metal a transient zone is formed, consisting of a multi-phase solid solution of tempered martensite plus austenite plus the  $\alpha$  phase alternating with sectors with austenite plus  $\alpha$  phase structure, i.e., austenite-ferrite. The material of the welded seam also contains a slight quantity of small dispersed carbides throughout its cross section. Figures 3; references 6: 5 Russian, 1 Western.

USSR

UDC 546.823'171:537.312.6

#### SUPERCONDUCTIVITY OF HIGHLY DISPERSED TITANIUM NITRIDE

Moscow IZVESTIYA AKADEMII NAUK SSSR. NEORGANICHESKIYE MATERIALY in Russian  
Vol 13, No 6, Jun 77 pp 1027-1029 manuscript received 24 Mar 76

DOMASHNEV, I. A., TROITSKIY, V. N., BERESTENKO, V. I. and GREBTSOV, B. M.  
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Abstract This work presents a study of the superconductivity of highly dispersed titanium nitride powder. The specimens for the study were produced by hydrogen reduction of  $TiCl_4$  in the stream of a nitrogen SHF discharge plasma. The titanium nitride consisted of crystals with cubic faceting with a mean diameter of about 500 Å. Mass spectral analysis indicated an impurity content of not over 0.8 wt.%, including not over 0.3 wt.% oxygen. The critical temperature for pressed briquettes of highly dispersed titanium nitride was comparable to the critical temperature for a massive specimen of the same composition, while the critical magnetic field for the briquettes was more than 10 times greater than that for the massive specimens. Figures 4; references 9: 4 Russian, 5 Western.

USSR

UDC 669.017.3:669.15-196.57

EUTECTOID TRANSFORMATION OF AUSTENITE DURING CONTINUOUS COOLING OF IRON  
WITH INTERDENDRITIC GRAPHITE

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 7,  
Jul 77 pp 76-77

GOYKO, G. G., Kramatorsk Industrial Institute

*[Abstract]* Samples made from chill cast iron were heated to 950°C for 30 minutes, furnace cooled at varying rates, and cooled in still air and in a jet of carbon dioxide to investigate the eutectoid transformation of austenite in cast iron with interdendritic graphite. A thermokinetic diagram of the eutectoid transformation was plotted and it was found that cooling this iron from the austenite-graphite state, at a rate providing for the occurrence of diffusion processes, leads to the development of free ferrite in the cooled structure. It was concluded that to prevent appearance of structurally free ferrite in iron with interdendritic graphite it is necessary to employ intensive cooling to promote the diffusionless martensitic transformation of austenite. Figures 4; references 7: 6 Russian, 1 Japanese.

USSR

UDC 669.14.018:539.385

KINETICS OF LOW-CYCLIC FATIGUE CRACK GROWTH IN MARAGING AND MEDIUM-ALLOY STEELS

Moscow METALLOVEDENIYE I TERMICHESKAYA OBRABOTKA METALLOV in Russian No 7,  
Jul 77 pp 6-12

PESTOV, I. V., OSTAPENKO, V. A., PERKAS, M. D., MALOLETNEV, A. YA.  
and KRETOV, N. A.

*[Abstract]* Results are presented of a study of the kinetics of fatigue crack growth under the action of fatigue loads with a limited number of cycles in maraging (N18K9M5T) and medium-carbon (30KhN2MFA) steels. The relative length of the period of crack nucleation was virtually independent of the magnitude of the cyclic stresses in the two steels. A period of slow crack growth was observed at a load of 165 kgf/mm<sup>2</sup> and characterized by the presence of fatigue microbands in the fracture which are ductile in

the maraging steel and brittle in the carbon steel. With increased crack length (period of rapid growth) the area undergoing microbands in the fracture diminished, while the portion of cupped fracture increased. At high cyclic stresses (260 and 360 kgf/mm<sup>2</sup>) there was no period of slow crack growth in either steel. The regularity of fatigue microbands in the fractures of the maraging steel showed its good homogeneity of properties, providing good fatigue strength at high cyclic impact loads in comparison with the medium-carbon steel. Figures 5; references 20: 11 Russian, 9 Western.

USSR

UDC 546.821.171.1:537.322

#### THERMO-EMF OF HIGHLY DISPERSED TITANIUM NITRIDE

Moscow IZVESTIYA AKADEMII NAUK SSSR. NEORGANICHESKIYE MATERIALY in Russian Vol 13, No 6, Jun 77 pp 1025-1026 manuscript received 22 Mar 76

DOMASHEV, I. A., TROITSKIY, V. N., GREBTSOV, B. M. (deceased) and KURKIN, Ye. N., Institute of New Chemical Problems, Academy of Sciences USSR

*[Abstract]* Compact specimens of highly dispersed titanium nitride were pressed in closed press molds at 10 kbar and 300°K. The residual porosity of the briquettes produced was 35-40%. The differential thermo-emf was measured by a compensation method in a stable thermal field with a temperature drop of 10-15°C. This method, using specimens sintered at 1600°K and made of titanium nitride produced by hydrogen reduction of TiCl<sub>4</sub> in the stream of a nitrogen SHF discharge plasma produced a value of  $\alpha$  of -5.5  $\mu$ v/C. Studies of cold pressed briquettes of highly dispersed nitride showed that at room temperature they have a value of  $\alpha$  of about -10  $\mu$ v/C, variation in porosity of specimens by 10-15% not significantly influencing the thermo-emf. This doubling of  $\alpha$  probably results from the peculiarities of the small particles. A study of the thermo-emf of granulated compact specimens of titanium nitride with a mean particle diameter of about 500 Å produced in a SHF discharge plasma shows that annealing at 1000°K results in an increase in the thermo-emf of the specimens by a factor of almost 5 in comparison to sintered specimens. Figures 1; references 4: all Russian.

USSR

UDC 546.27.171.1

COMPRESSIVE STRENGTH AND THERMAL STABILITY OF POLYCRYSTALLINE CUBIC BN

Moscow IZVESTIYA AKADEMII NAUK SSSR. NEORGANICHESKIYE MATERIALY in Russian  
Vol 13, No 6, Jun 77 pp 1022-1024 manuscript received 17 Jun 76

VERESHCHAGIN, I. F.,(deceased) GLADKAYA, I. S., SLESAREV, V. N.,  
Institute of Physics of High Pressures

*[Abstract]* This work presents a study of the compressive strength and thermal stability (in air and in a vacuum) of polycrystalline CBN. The fracture of polycrystalline specimens under the influence of monaxial compression at room temperature was studied on a laboratory three-ton press using cylindrical specimens  $d = 3.7$  mm,  $h = 2.35$  mm with variation from parallelism of end planes not over 0.002 mm. The specimens were produced by various methods. It was found that the highest compressive strength ( $320 \pm 20$  kg/mm<sup>2</sup>) was that of specimens synthesized using a solvent. The compressive strength of specimens produced by solid-phase conversion from hexagonal BN was 25% lower. The thermal stability of the specimens depends on the method of their production and the medium of heat treatment. Thermal stability in a vacuum is higher than in air. Specimens produced by solid-phase conversion were more resistant to heating, a result of the absence of products of crystallization of the solvent. Figures 2; references 5: all Russian.

USSR

UDC 347.77:519.283:608.001:62.001:669.017

USE OF CERTAIN METHODS OF PREDICTION FOR THE CREATION OF NEW MATERIALS

Kiev POROSHKOVAYA METALLURGIYA in Russian No 6, Jun 77 pp 100-107  
manuscript received 20 May 75

SHVEDKOV, Ye. L., ZABOLOTNYY, L. V. and MIKHASHINA, L. M., Institute of Problems of Material Science, Academy of Sciences UkrSSR

*[Abstract]* This is the first in a series of articles dedicated to solution of the specific problem of creation of a sintered structural antifriction material. The methods presented for prediction, garnered from the technical and patent literature, can be successfully used in the creation of both

antifriction and other materials. Prediction, it is concluded, must be undertaken both from the pragmatic and from the gnoseologic points of view, in order to assure that the limited resources available for research are expended in the most favorable directions and areas. The basis for prediction, particularly in the area of the creation of new materials, must be patent information, supplemented by parametric sources such as monographs, articles, reports, catalogues, etc. The use of characteristic tables for weighing of information, expert estimates for ranking of goals and subgoals, and approaches involving extraction of additional information from patents is convenient in the composition of a prediction of the selection of a promising direction of research from among the many possible directions. This article presents no new methods of prediction, but rather is concerned with optimal utilization of known methods in the area of creation of new materials. The methods presented will be described in greater detail in future articles on a specific theme--the development of a sintered anti-friction material; this article merely presents a general diagram of their application. Figures 1; references 15: all Russian.

USSR

UDC 532.78;621.791.011

INFLUENCE OF CRYSTALLIZATION OF THE VITREOUS PHASE ON WELDING OF CERAMICS WITH METALS

Moscow FIZIKA I KHIMIYA OBRABOTKA MATERIALOV in Russian No 3, May-Jun 77  
pp 139-144 manuscript received 6 Aug 76

METELKIN, I. I., PUZYREV, E. I., SHAPIRO, G. M., DORONKINA, A. A., LAPINA, N. I. and NIKIFOROVA, T. V., Moscow

[Abstract] Electron microscope and x-ray phase analysis methods are used to show that the vitreous melt formed in the surface layer of A-995 ceramic as a result of burning of the paste PS-11 ( $MnO \cdot Al_2O_3 \cdot SiO_2$  with  $Cr_2O_3$  added) and the vitreous phase of 22KhS ceramic during subsequent heating is catalytically crystallized. Preliminary crystallization of the vitreous phase component of the ceramic, performed before welding of the dielectric to a metal, in many cases has a significant influence on the strength of the welded joints produced. The catalytic crystallization involves separation of crystals of  $3MnO \cdot Al_2O_3 \cdot 3SiO_2$  and  $MnO \cdot Al_2O_3$ . The softening point of the vitreous phase is increased during this reaction. These structural conversions must be considered in the development of

technological processes for joining ceramics and metals. Additional heating in the crystallization mode at about 2°C/min immediately before welding results in a significant decrease in the strength of the welded joints. This effect is not significantly observed with 22KhS ceramic. The results produced can be extended to other systems involving the catalysts Cr<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub>, etc.: in particular, they can be used to study the crystallization of various glasses used for the metallization of ceramics. Figures 5; references 10: all Russian.

USSR

UDC 535.211

FEATURES OF DIMENSIONAL WORKING OF MATERIALS BY THE RADIATION OF RUBY LASERS OPERATING IN THE FREE-OSCILLATION AND SINGLE-PULSE MODES

Moscow FIZIKA I KHIMIYA OBRABOTKA MATERIALOV in Russian No 3, May-Jun 77  
pp 35-38 manuscript received 23 Aug 76

KONONOV, V. A., and MIKHNOV, S. A., Minsk

*[Abstract]* Experimental results are presented from investigations involving working of materials by the laser projection method, in which the specimen is placed in the plane of the image of a mass illuminated by laser radiation. This method can produce images of complex configuration and at the same time can process areas considerably larger than the focal spot. In this article, areas of massive materials with much greater dimensions (around 1 mm) are worked by the radiation of a ruby laser in the free-oscillation, single-pulse and single-pulse-train modes. In specific technological applications, for example the application of inscriptions and characters in the millimeter size range on parts of various materials, the single-pulse mode is most suitable. The single-pulse mode is advantageous from the energy standpoint, from the standpoint of visibility of marks produced and from the standpoint of insignificance of heat conductivity effects, which may lead to thermal distortion of the characters impressed. The pulse-train method has these same advantages, and is most promising for the production of images with predetermined mean irregularity height. Figures 2; references 8: all Russian.

USSR

UDC 539.4.019.3:535.211

SURFACE HARDENING OF PARTS OF GRAY CAST IRON BY CONTINUOUS LASER RADIATION

Moscow FIZIKA I KHIMIYA OBRABOTKA MATERIALOV in Russian No 3, May-Jun 77  
pp 28-34 manuscript received 24 Aug 76

KOKORA, A. N., ZHUKOV, A. A. and EPSHTEYN, L. Z., Moscow

**[Abstract]** As specimens of gray cast iron with various chemical compositions and various microstructures are passed through the radiation of a continuous laser at predetermined rates, a surface-hardening effect is achieved owing to the formation of ledeburite cementite upon partial melting of the metal. This article studies the influence of the radiation conditions and initial microstructure of the metal on the depth, structure and microhardness of the hardened layer. The new technological process has been tested in the production of a number of parts for textile and other machinery. The process produces a very hard surface layer with a chilled structure of varying depth, the surface quality after further finishing varying inversely with depth. The best results as to depth and density of the chilled layer are produced in pearlitic cast iron with fine plate graphite. In cast iron with coarse graphite plates, the plates are not completely dissolved in the melt. In cast iron with "graphite eutectic" the hardness of the chilled zone is somewhat reduced. Figures 7; references 5: all Russian.

USSR

UDC 539.4.019.3

FORMATION OF A CRATER AT THE TIP OF A CRACK UNDER THE INFLUENCE OF A POWERFUL LOCAL ELECTROMAGNETIC FIELD

Moscow FIZIKA I KHIMIYA OBRABOTKA MATERIALOV in Russian No 3, May-Jun 77  
pp 18-23 manuscript received 27 Apr 76

GOLOVIN, Yu. I., FINKEL', V. M. and SLETKOV, A. A., Tambov

**[Abstract]** A simple current method is used to produce highly intensive local fluxes of electromagnetic energy at the tip of an edge crack in metal as a strong current pulse flows around the crack. The experiments were performed on polished plates of iron, copper, aluminum and steels (types 45, 60G and Kh18N9T) measuring 50 x 15 x 0.5 mm with an edge crack 6 mm long.